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ABSTRACT

This second volume contains the remainder of the experiments and instructional material developed at the NDEA Institute. Included are seven units on polymers, three units on electronics, three units on graphic arts, 10 units on fuels and lubricants, and one unit on textiles. A list of reviewed films and source availability is appended. Volume I is available as VT 008 258. [Not available in hard copy due to marginal legibility of original document.] (GR)

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ED039315

# INSTRUCTIONAL UNITS
for
INDUSTRIAL MATERIALS

Prepared by: Industrial Arts Educators
attending the
NDEA Title XI Institute for
Advanced Study in Industrial Arts

San Jose State College
San Jose, California
June 24-August 2, 1968

VOLUME II OF TWO VOLUMES

(Contains Information on Polymers, Electronics, Graphic Arts, Fuels & Lubricants, and Textiles, as listed on the Table of Contents included with Volume I.)

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VT008259

POLYMERS

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: L. Russell Pickett
Hamlin Junior High School
Springfiled, Oregon

INSTRUCTIONAL LEVEL: Jr. High, High School, Junior College

TITLE: Polymers - Acrylics

PRESENTATION TIME: Lecture-Demonstration 6 - 10, Student Experiment 10 - 20 hours.

INTRODUCTION:

Acrylic is the chemical name for one of several kinds of plastics in the big family of thermoplastics. This plastic material is probably the most familiar to most of us, because of its various colors and textures when used in homes and purchasing it at your local hobby shop. Most of you will recognize some of the trade names of this material: Plexiglas, lucite, evr-kleer, gerlite and polycast. Much of this material is used clear, or is referred to as transparent,also much of the material is translucent.

OBJECTIVES:

1. The student should be able to recognize this material as one in the family of thermoplastics.
2. The student should be able to give two or three ways this material differs from other thermoplastic materials.
3. The student should become familiar with the physical properties of this material.
4. The student should become acquainted with the industrial use of this plastic material.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Polymers (Plastics)

INTER-RELATION WITH OTHER SUBJECTS:

1. This subject could be introduced as a short unit in Wood, Metal or General Shop courses of Industrial Arts
2. Team teaching with the 8th grade General Science teacher would be possible, where he emphasized the theory and the IA teacher reinforced it with experiments and projects in the IA lab.
3. Fits nicley under 9th grade IPS science program which is based on chemistry, experimentation, and properties of materials.

USE IN INDUSTRY:

Applications in industry are aircraft glazing, internally illuminated fluorescent lights, architectural panels, skylights and demonstration models. Acrylics are divided into three main product groups: cast sheet, molding powder and high-impact molding powder. All molding powders can be used in all injection and extrusion equipment. The crystal clarity of the acrylics, along with the ease with which they can be decorated by vacuum metallizing, spray painting, hot stamping and other methods are important characteristics for many applications. This material is one of the easiest plastic materials to work, requiring a small amount of equipment. The material is one of the least expensive plastic materials, which gives the students many opportunities to find out the working properties of this material, such as burning rate, transparency, hardness, water absorption, solvents and adhesives.

MATERIALS AND EQUIPMENT:

acid swaps (one doz)
aerosol spray paint cans (assorted colors)
eye droppers (one doz)
coloring dyes
holding jigs - thermoformed shapes (assortment)
strip heater
heat gun
bunsen burner
light source (flashlight or small table lamp)
six doz pint & half pint glass jars (wide mouth)
various samples of acrylic (cast sheet) materials, colors and
    textures.
5 or 6 solvents for this material - incl. acetone
5 or 6 adhesives for this material to incl. ethylene dichloride
oven, thermostat controlled
extrusion machine if available
air pressure forming machine if available
small sandblasting machine if available
injection molding machine if available
assorted manufacturing samples: auto taillights, metallized
    components, light fixture shades, etc.

EDUCATIONAL MEDIA:

1. Films (for ordering information - see appendix)
    PLASTICS IS YOUR BUSINESS
    THE MAGIC MOLECULE
    THE COMPOSITION AND PROPERTIES OF PLASTICS
    THE SHAPE OF PLASTICS
    WHAT CAN THE MATTER BE?
    PROSPECT FOR PLASTICS
    ORIGIN AND SYNTHESIS OF PLASTICS MATERIALS
    NEW WORLD OF CHEMISTRY
    PLASTICS, INDUSTRIAL PROCESSES AND PRODUCTS
    METHODS OF PROCESSING PLASTIC MATERIAL
    MANUFACTURE OF PLASTICS
    PORTRAIT IN PLASTICS
    WHO IN THE WORLD IS SWEDLOW?
    MERLON POLYCARBONATE
    CONSTRUCTION AND OPERATION OF PLASTICS SCREW EXTRUDERS
    EXTRUSION STUDIES WITH TRANSPARENT BARRELS AND DIES
2. Transparencies
    #1 - #14 - attached to unit
3. Audio-Visual Materials
    overhead projector
    8mm single concept projector
    16 mm sound projector
    drill size chart
    tap and die chart
    safety charts on machine tools
    chart of extrusion machine illustrating the parts
    chart of injection molding machine, illustrated operations and parts
    acrylic rod with knot tied in it for light transmission illustration
    molecular models
4. Single concept film list - super 8 mm silent
    (all instructor made or purchased commercially if avaialble)
    operation of a sandblaster
    operation of shop designed air pressure forming machine
    operation of extrusion molding machine
    operation of the injection molding machine
5. Slide series
    The introductory group of slide needs to be developed by the instructor or purchased from the following:

Kitco Division of the Henry Company
6405 East Kellog Street
Wichita, Kansas
Filmstrip and record at $18.50 - INTRODUCTION TO PLASTICS - 35 mm. film strip and accompanying 33 1/3 record, color. 20 minutes.

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT:

SAFETY:

1. Many of these materials are acid in nature and are not easily removed from clothes - wear shop coat.
2. When cutting or sanding wear eye and/or face protection.
3. Most of these materials are very inflammable, use use considerable caution when near heat. DO NOT WORK WITH THESE MATERIALS NEAR OPEN FLAME.

PRESENTATION: (Instructor)

A. Introduction -(importance of plastic to our society today) Transparency 1, Films 1 & 2.
B. Atoms & Molecular structure of Polymers - Transparencies 2, 3, 4, 5, Molecular Models, Films #, 4, 5, 6.
C. Polymerization - Demonstration on making simple nylon, Transparencies 6 & 7, Molecular Models, Films 7 & 8
D. Plastic Families - Transparencies 8 & 9, a common sample of each type of plastic, Film 9.
E. Acrylic Structure - Trans. 10.
F. Producing Acrylics - Trans. 11 & 12, Films 10, 11, 12.
G. Properties of Acrylics - Demonstration on Impact Strength, Trans. 13, Film 13.
H. Light Transmission (Clarity) - Demonstration with polished edge & carved letters in face of material for edge lighting effect, Trans 13, Acrylic rod tied in a knot - polished at both ends.
I. Heat forming (Plastic Memory) - Demonstration on heat forming a small project, Film 14.
J. Adhesion - Demonstration of the various methods of joining two pieces of acrylic.
K. Solvents - Illustration of student experiment, Trans.13
L. Dyeing - Demonstration on three types of dyeing, Trans 12, samples of colored acrylic plastic.
M. Cutting-Shaping & Texture - Demonstrations: hand & power tools for cutting, drilling, filing, sanding & buffing, sandblasting, coating by paint. Charts on

safe operation of power tools, Single Concept film on Operation of Sandblaster, Shop color chart for available colors.

N. Fabrication
   1. Fasteners - demonstration on drilling and tapping of acrylic material, Tap and Die Chart, and Drill Chart.
   2. Air Pressure Forming - Demo. on making a small free-form dish, Trans. 14, Single concept film on operation of shop designed air pressure forming machine.
   3. Extrusion - Demo. on this machine, Chart on machine operation and parts, Single concept film on the operation of Extrusion Molding Machine, Films 15 & 16
   4. Injection Molding - demo on this machine, Chart on parts of the machine and operational procedures, Single concept film on the operation of the injection molding machine.

PRESENTATION: (student)

topic	student assignment	student experiment or project
A	list plastic materials known, by uses	none
B	review knowledge of atoms and molecular structure	construct other molecular structures from models
C	none	construct other polymer "mers" with models
D	list samples of plastic presented	none
E	read about acrylics in ref & textbooks	none
F	study production of acrylic resin	none
G	find burning rate on properties trans. & impact strength	test burning rate of various acrylics test impact strength
H	find transmittance on properties chart - text	expr. with different angles of bends for light transmission
I	find correct temp for forming various thicknesses acrylics	twist or form sample pieces when heated, then reheat and observe. small projects can be made.

J	list as many types of adhesives as possible that will work on this	test as many as possible to fing the strongest and best. project work.
K	find solvents that will work on acrylics	experiment with the solvents and record results - expr. with solvents as cleaners
L	check out available dyes	experiment with 2 or 3 to find best for your project
M.	review safety rules, find best bandsaw blade, review operation of sandblaster	experiment with handsaws, test erosion with disc sander, test for light transmission after sandblasting
N.	review safety	attempt project on one of these machines

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE:

topic question to be answered during the unit

A. Are there only two or three plastic materials used around the home?
Why are plastics important to us as a society?
B. How do materials differ in molecular structure?
How are the fossil fuels important to polymers?
C. What are the basic elements needed for polymerization?
What is meant by a "mer" in polymerization?
How many molecules are involved in polymerization?
D. What is the difference between the two major families of plastics?
E. How does the molecular structure of acrylic differ from polystyrene or another polymer?
F. How does a reactor operate in making acrylic resin?
G. How do the properties of acrylic materials compare with polystyrene?
H. Is there a thermoplastic material that has better light transmission qualities than acrylic, if so, which one is it?
I. Why does this plastic material seek its original shape when reheated after forming?
J. Can you describe the action that takes place when glueing with a solvent type adhesive?
K. Which solvent worked the best on this material, from the results of your testing?

L. Is there a difference between transparent and translucent acrylic materials?

M. What should be done with the surface of acrylic material before coating with a paint?

N. How many different machine processes can be used with any form of this material in making useful plastic items?

UNIT EVALUATION:

1. Observe the students as they are performing the experiments, for clues to future presentations of this unit.
2. To measure to a slight degree the success of the unit, you might assign each student a performance typ e of test operation or a project to see if they (individually) have gained knowledge of that activity.
3. Each student could have four or five samples of plastic material (one - acrylic). By performing any test they knew about and wished to try, identify which one is the acrylic sample.
4. Determine the definite length of time by presenting this unit. How many periods for instruction, experimentation, and student projects.
5. Each instructor should try experimental ideas of his own, do not let this outline limit your breadth or depth of instruciton.

DEFINITION OF TERMS:

1. Acrylic ester - of acrylic acid, or of a structural derivative of acrylic acid, e.g., methyl methacrylate
2. Compressive strength - crushing load at the failure of a specimen divided by the original sectional area of the section.
3. Crazing - fine cracks which may extend in a network on or under the surface or through a layer of a plastic material.
4. Creep - dimensional change with time of a material under load, following the initial instantaneous elastic deformation. Creep at room temperature is sometimes called cold flow.
5. Crystallinity - a state of molecular structure in some resins which denotes uniformity and compactness of the molecular chains forming the polymer.

6. Dimensional stability - ability to retain the precise shape in which it was molded, fabricated or cast.
7. Elongation - fractional increase in length of a material stressed in tension
8. Extrusion - compacting of a plastic material and the forcing of it through an orifice in more or less continuous fashion.
9. Flexural strength - strength in bending, expressed as tensile stress of the outermost fibers of a bent test sample at the instant of failure.
10. Modulus of Elasticity - ratio of stress to strain in a material that is elastically deformed.
11. Plastic deformation - change in dimensions of an object under load that is not recovered when the load is removed; opposed to elastic deformation.
12. Tensile strength - pulling stress, in PSI, required to break a given specimen
13. Yield Value/strength = lowest stress at which a material undergoes plastic deformation. Below this stress, the material is elastic; above it, viscous.

REFERENCES: (see references - cellulosics unit)

THE PRODUCTION OF NYLON 6/6 IN ILLUSTRATING POLYMERIZATION

INTRODUCTION:

This is a simplified version of the industrial application.

MATERIALS & EQUIPMENT:

4.4 grams of 1,6 - hexanediamine
50 mills of H_2O
2 mills of sebacoyl chloride
100 mills of carbon tetrachloride
1 - 500 cc beaker
overhead projector and screen
1 pr tongs
8" piece of 1/2" dowel

UTILIZATION IN THE TEACHNG LEARNING ENVIRNOMENT

SAFETY:

1. Safety glasses required
2. Mix chemicals in well ventilated area - fumes injurious to lethal
3. Bring into classroom mixed - due to dangerous nature of fumes

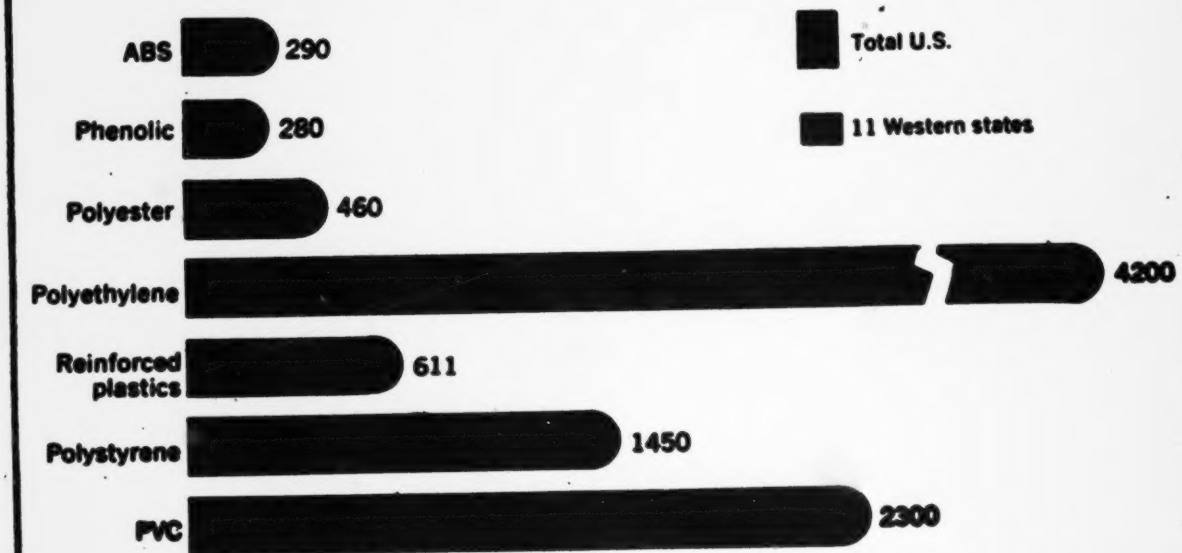
PRESENTATION:

1. Mix the sebacoyl chloride in the carbon tetrachloride & put into a 500 cc beaker
2. Do not put other chemicals into beaker until mixed in a separate container
3. Pour the 1,6 hexanediamine and water slowly into the beaker of sebacoyl and carbon tetrachloride
4. These will form two layers of liquids with a membrane in between.
5. Place the beaker on the overhead projector and project
6. With a pair of tongs reach into the beaker and pull up the membrane in the center
7. The membrane will become visible as it is pulled away from the beaker walls
8. A strand of nylon will be drawn from the membrane
9. Place the strand of nylon on a piece of dowel and rotate
10. The strand continues to be drawn as long as the two solutions unite to form the strand.

PLASTICS OUT WEST:

ALPHA OLEFIN PLANT of Chevron Chemical Co. at Richmond, Calif., superimposed over map of the 11 western states, typifies the regional aspects of the U.S. plastics industry.

1968: How western plastics sales compare with total U.S.*



*MODERN PLASTICS estimates.

ATOMS, SYMBOLS, VALENCE NO. & STRUCTURE

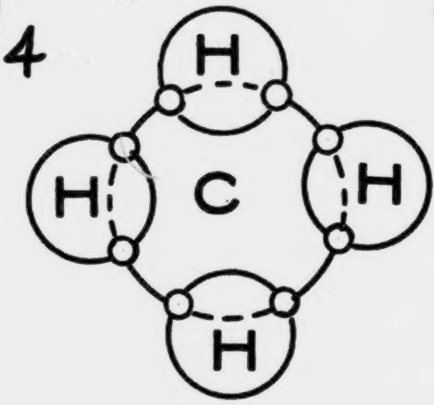
ATOMS	SYMBOL	VALENCE NO.	STRUCTURE
Hydrogen	H	1	-H
Fluoride	F	1	-F
Chlorine	CL	1	-CL
Iodine	I	1	-I
Bromine	Br	1	-Br
Oxygen	O	2	-O-
Sulfur	S	2	-S-
Nitrogen	N	3	$-\overset{\mid}{N}-$
Carbon	C	4	$-\overset{\mid}{\underset{\mid}{C}}-$
Silicon	Si	4	$-\overset{\mid}{\underset{\mid}{S}}-$

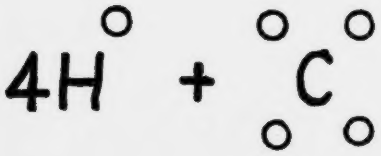
COVALENT BONDS

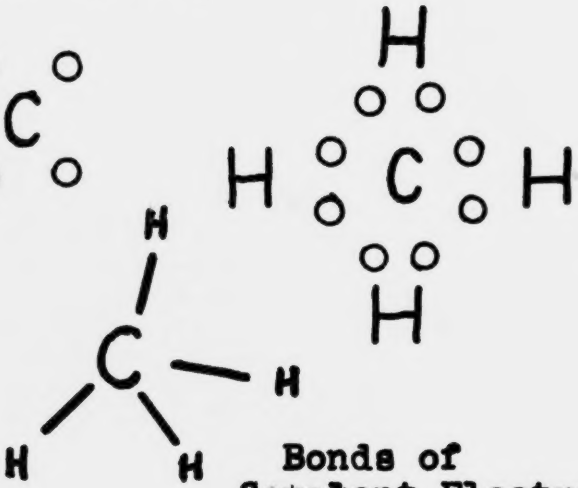
COMPOUNDS

Methane (Marsh Gas)

CH_4



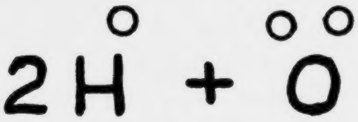


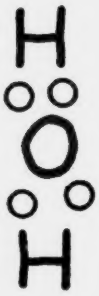

H
H C H
H
H
C
H
H
H

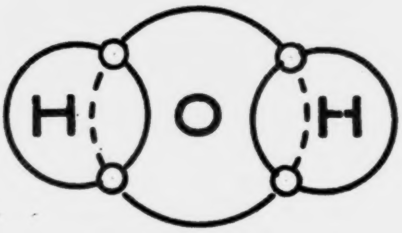
Bonds of Covalent Electrons

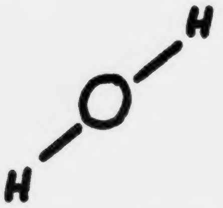
Water

H_2O





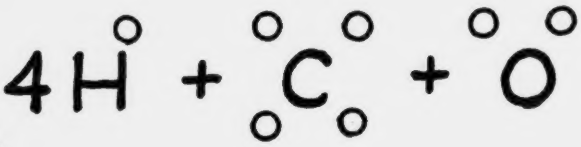


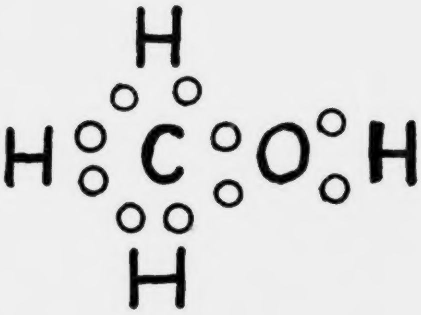


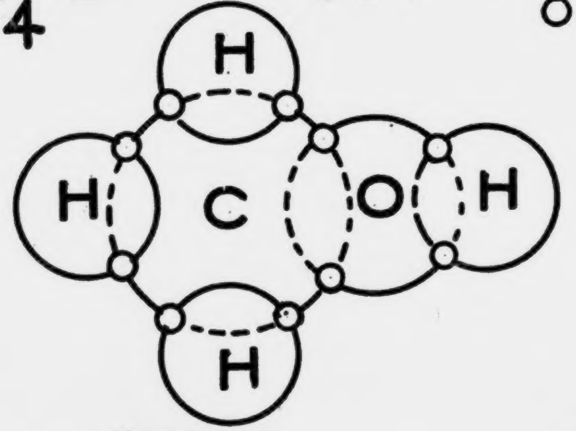
Bonds of Covalent Electrons

Methyl Alcohol

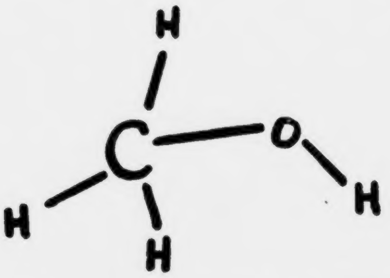
CH_4O







Monomer



Bonds of Covalent Electrons

Formulas, Atoms & Structures

FORMULAS

1. Molecular — Indicate kind and number of atoms in molecule.

2. Structural — Also indicate chemical bonds between atoms.

Water

H_2O

Two atoms of hydrogen

One atom of oxygen

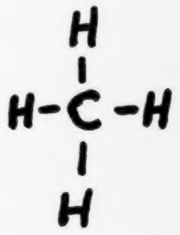
$H-O-H$

Methane(Marsh Gas)

CH_4

Four atoms of hydrogen

One atom of carbon



$H-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-H$

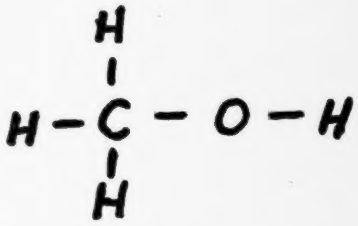
Methyl Alcohol

CH_4O

Four atoms of hydrogen

One atom of carbon

One atom of oxygen



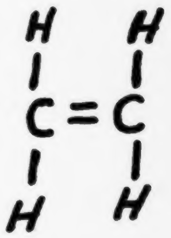
$H-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-O-H$

Ethylene

C_2H_4

Four atoms of hydrogen

Two atoms of carbon



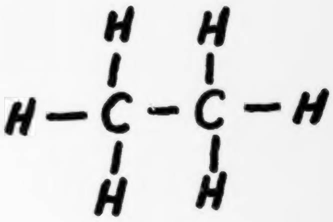
$\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}=\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}$

Ethane

C_2H_6

Six atoms of hydrogen

Two atoms of carbon



$H-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-H$

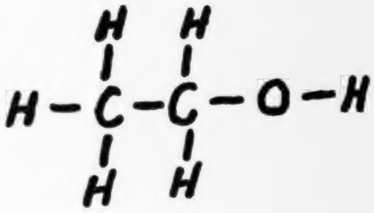
Ethyl Alcohol

C_2H_6O

Six atoms of hydrogen

Two atoms of carbon

One atom of oxygen



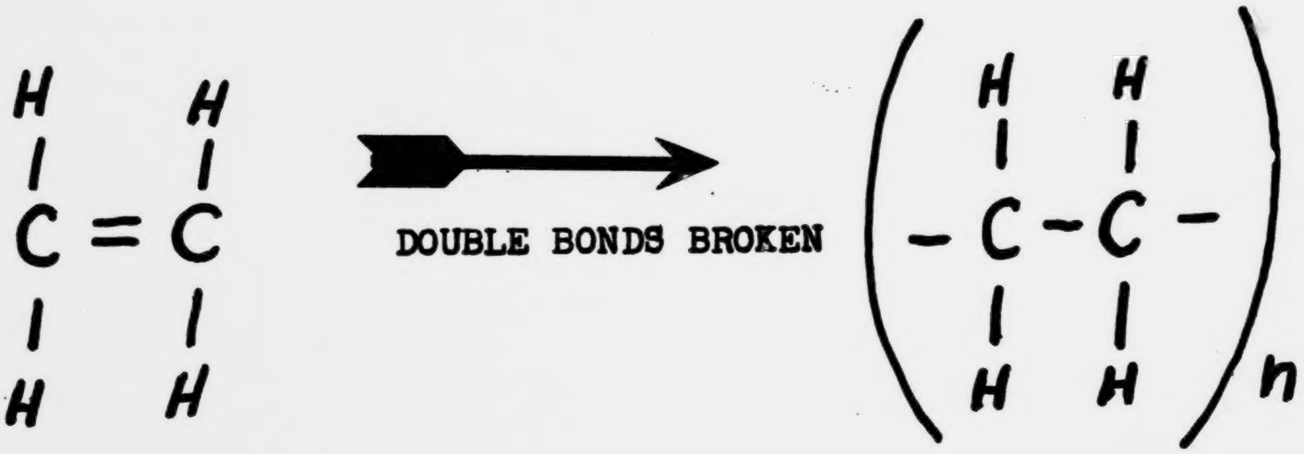
$H-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-O-H$

POLYMERIZATION

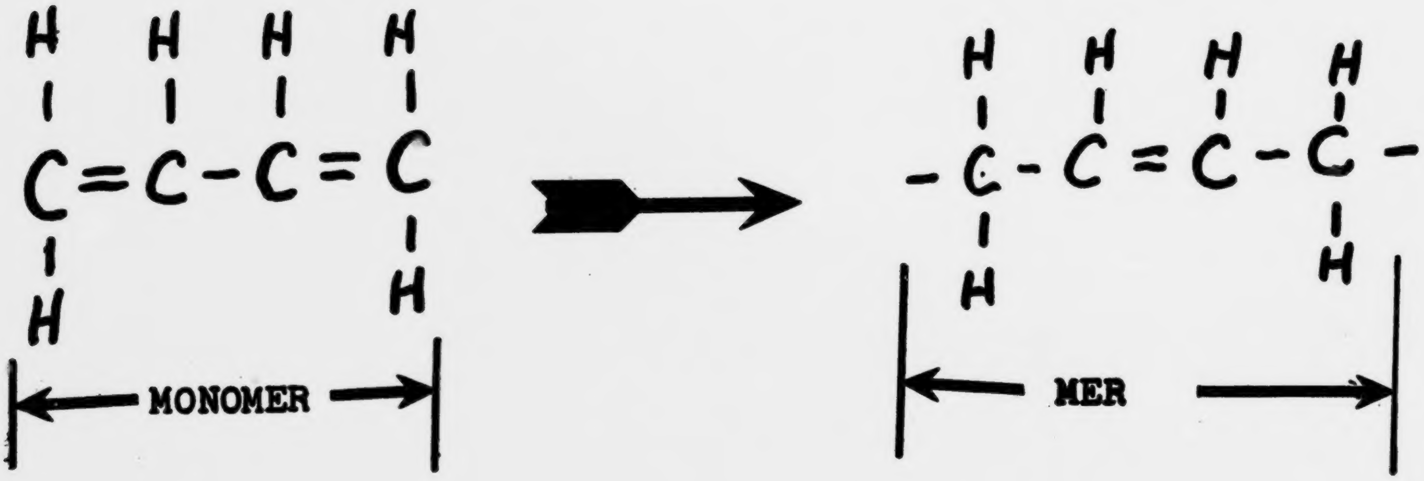
Polyethylene

(MANY MOLECULES OF ETHYLENE JOINED TOGETHER)

$$n\left(CH_2=CH_2\right) \xrightarrow[\text{HEAT - LIGHT PRESSURE}]{\text{(CATALYST)}} \left(CH_2-CH_2\right)_n$$


DOUBLE BONDS BROKEN

BIFUNCTIONAL
TWO REACTION SITES
FOR OTHER MOLECULES


MONOMER
MER

POLYMERS → MANY MERS

Types of Polymerization

ADDITION TYPE

Ethylene   Water   Ethyl Alcohol

$$CH_2=CH_2 + HOH \rightarrow CH_3-CH_2OH$$

Ethylene   Polyethylene

$$CH_2=CH_2 \xrightarrow[\text{Heat- light Pressure}]{\text{Catalyst}} (CH_2-CH_2)_n$$

CONDENSATION TYPE

Acetic Acid   Ethylalcohol

$$CH_3-COOH + HOC_2H_5$$ ↲

Ethyl Acetate   Water

$$\rightarrow CH_3COOC_2H_5 + H_2O$$

POLYMERS

THE THERMOPLASTIC FAMILY

ACRYLIC	SIGNS AUTO TAIL LIGHTS CONTACT LENSES CONTROL PANELS
CELLULOSIC	PACKAGING TOOTH BRUSHES STEERING WHEELS EYEGLASS FRAMES
POLYAMIDE (NYLON)	GEARS FABRICS SHOWER HEAD VALVES PIPING
POLYOLEFIN POLYETHYLENE POLYPROPYLENE	SQUEEZE BOTTLES PACKAGING INSULATING COVERS CONTAINERS
POLYSTYRENE	FOOD CONTAINERS BATTERY CASES CABINETS INSULATION PIPING
VINYL	FLOOR COVERING RAIN WEAR SCREENING CEILING FIXTURES

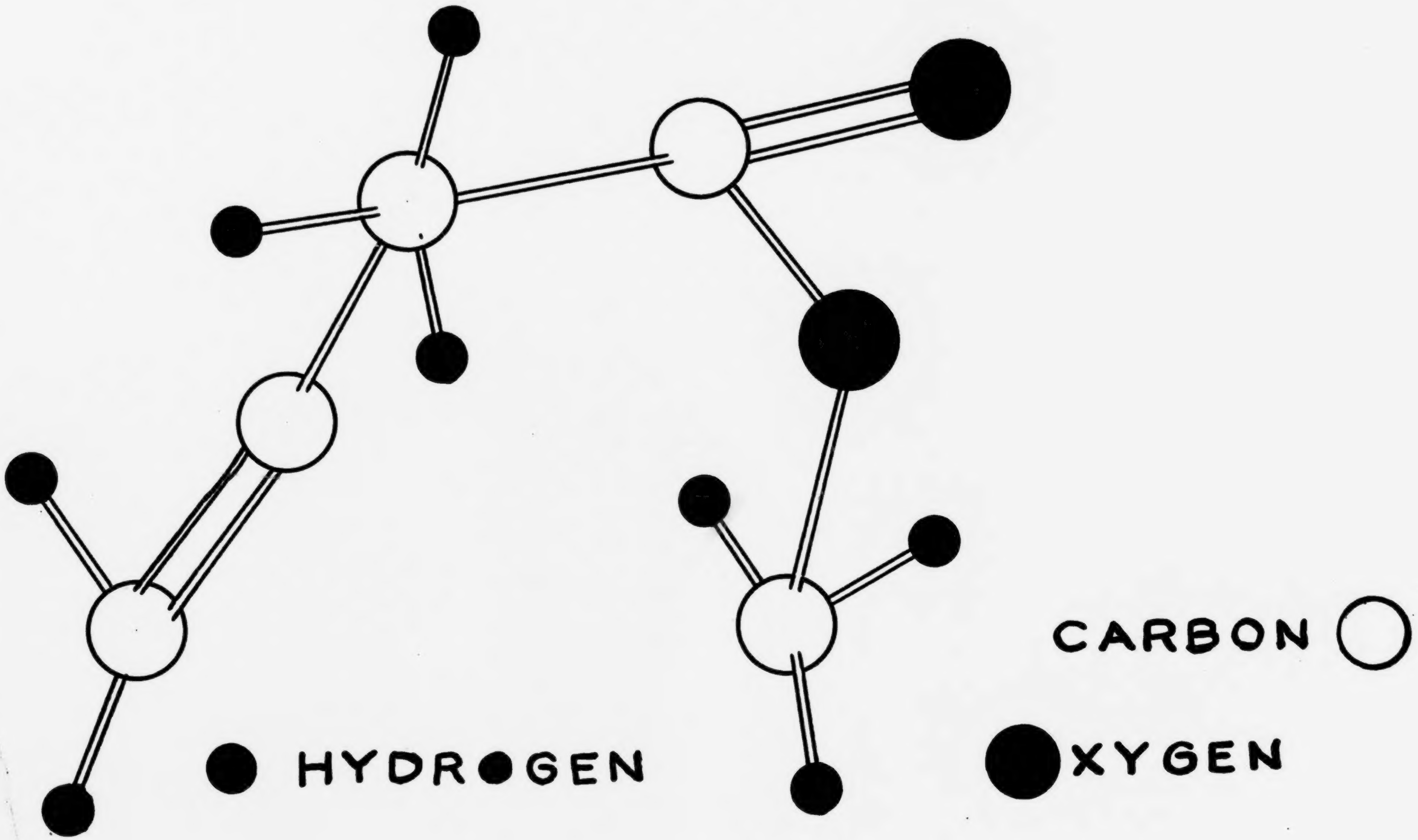
POLYMERS

THE THERMOSET FAMILY

AMINO	DISHES COUNTERTOP MATERIALS ADHESIVES SWITCHES SIZINGS
CASEIN	KNITTING NEEDLES BUTTONS DRESS BUCKLES NOVELTIES
EPOXY	ADHESIVES SURFACE COATINGS ELECTRICAL COMPONENTS
PHENOLIC	APPLIANCE HANDLES T-V CABINETS DISTRIBUTOR CAPS ADHESIVES
POLYESTER	BOAT & AUTO STRUCTURES COATINGS SPORTS EQUIPT. BUILDING MATERIALS
SILICONE	MOLD RELEASES TAPE ADHESIVES ELECTRICAL COMPONENTS
URETHANE	FOAMS INSULATION COATINGS RUG PADS AIRCRAFT PARTS

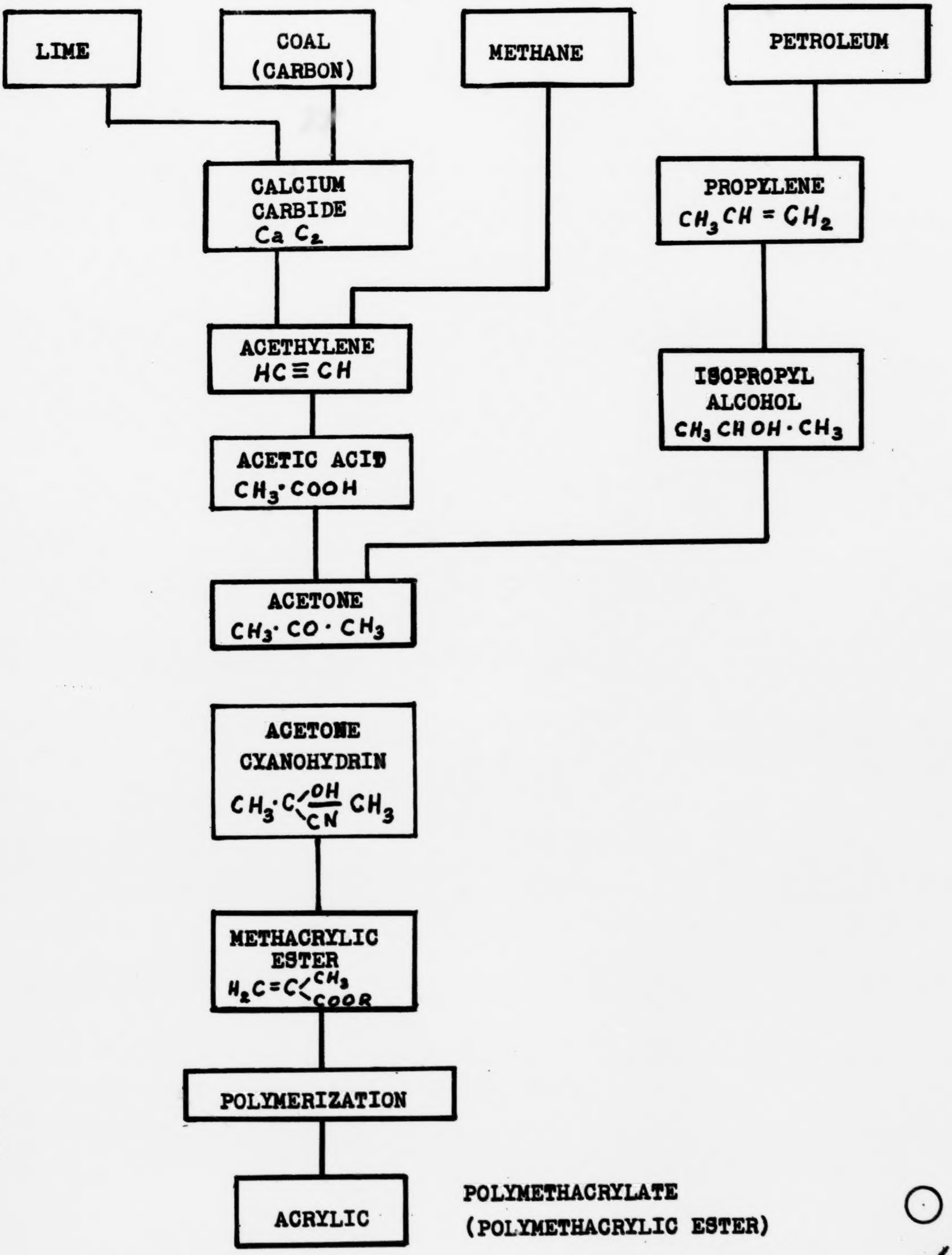
SYNTHETIC POLYMERS

ACRYLICS

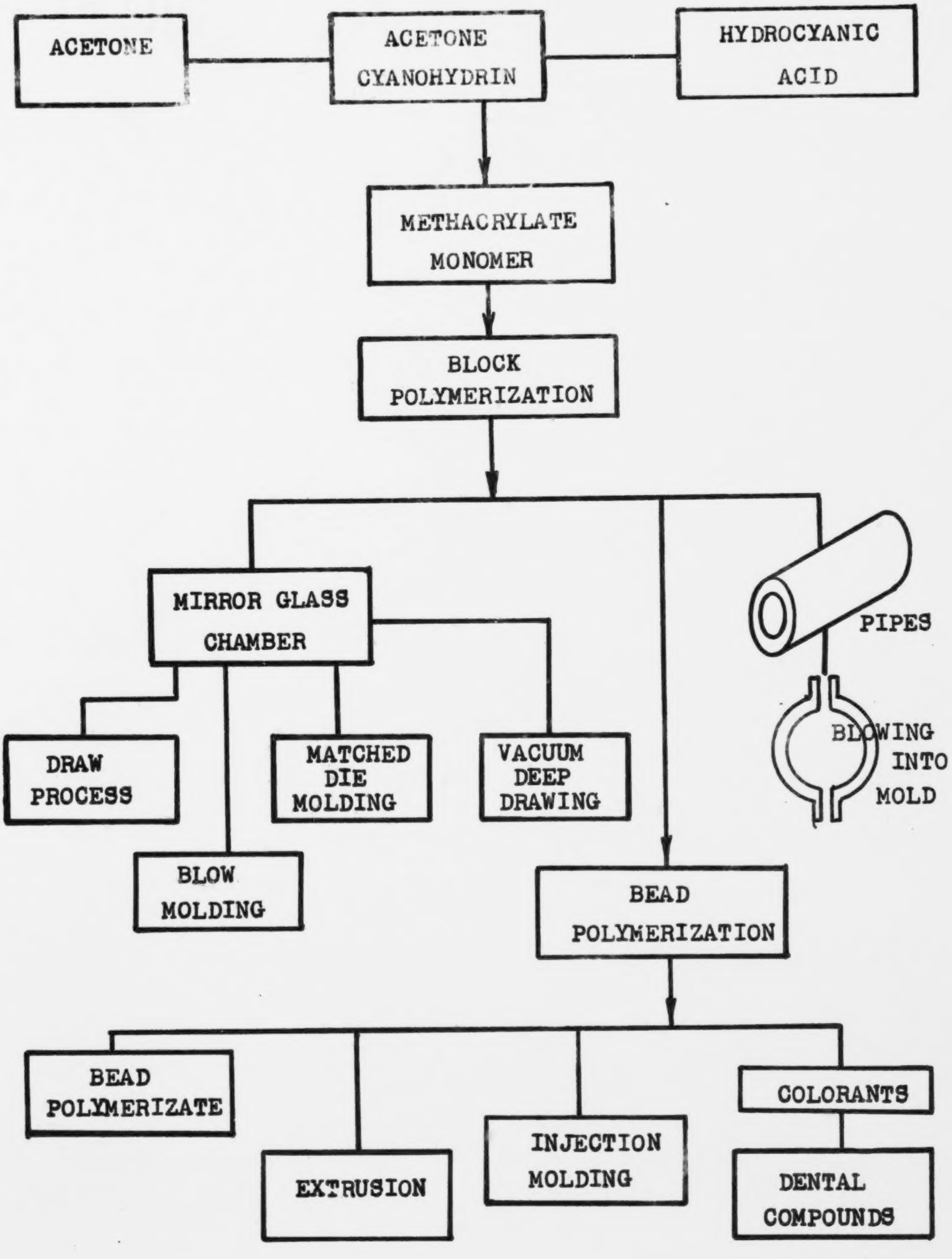

CARBON
HYDROGEN
OXYGEN

THE CHEMICAL STRUCTURE OF ACRYLICS

IN Line CHART FORM


LIME
COAL (CARBON)
METHANE
PETROLEUM
CALCIUM CARBIDE
CaC_2
PROPYLENE
$CH_3CH = CH_2$
ACETHYLENE
$HC \equiv CH$
ISOPROPYL ALCOHOL
$CH_3CHOH \cdot CH_3$
ACETIC ACID
$CH_3 \cdot COOH$
ACETONE
$CH_3 \cdot CO \cdot CH_3$
ACETONE CYANOHYDRIN
$CH_3 \cdot C\langle^{OH}_{CN} CH_3$
METHACRYLIC ESTER
$H_2C=C\langle^{CH_3}_{COOR}$
POLYMERIZATION
ACRYLIC
POLYMETHACRYLATE
(POLYMETHACRYLIC ESTER)

PRODUCTION OF ACRYLICS


ACETONE
ACETONE CYANOHYDRIN
HYDROCYANIC ACID
METHACRYLATE MONOMER
BLOCK POLYMERIZATION
MIRROR GLASS CHAMBER
PIPES
BLOWING INTO MOLD
DRAW PROCESS
MATCHED DIE MOLDING
VACUUM DEEP DRAWING
BLOW MOLDING
BEAD POLYMERIZATION
BEAD POLYMERIZATE
COLORANTS
EXTRUSION
INJECTION MOLDING
DENTAL COMPOUNDS

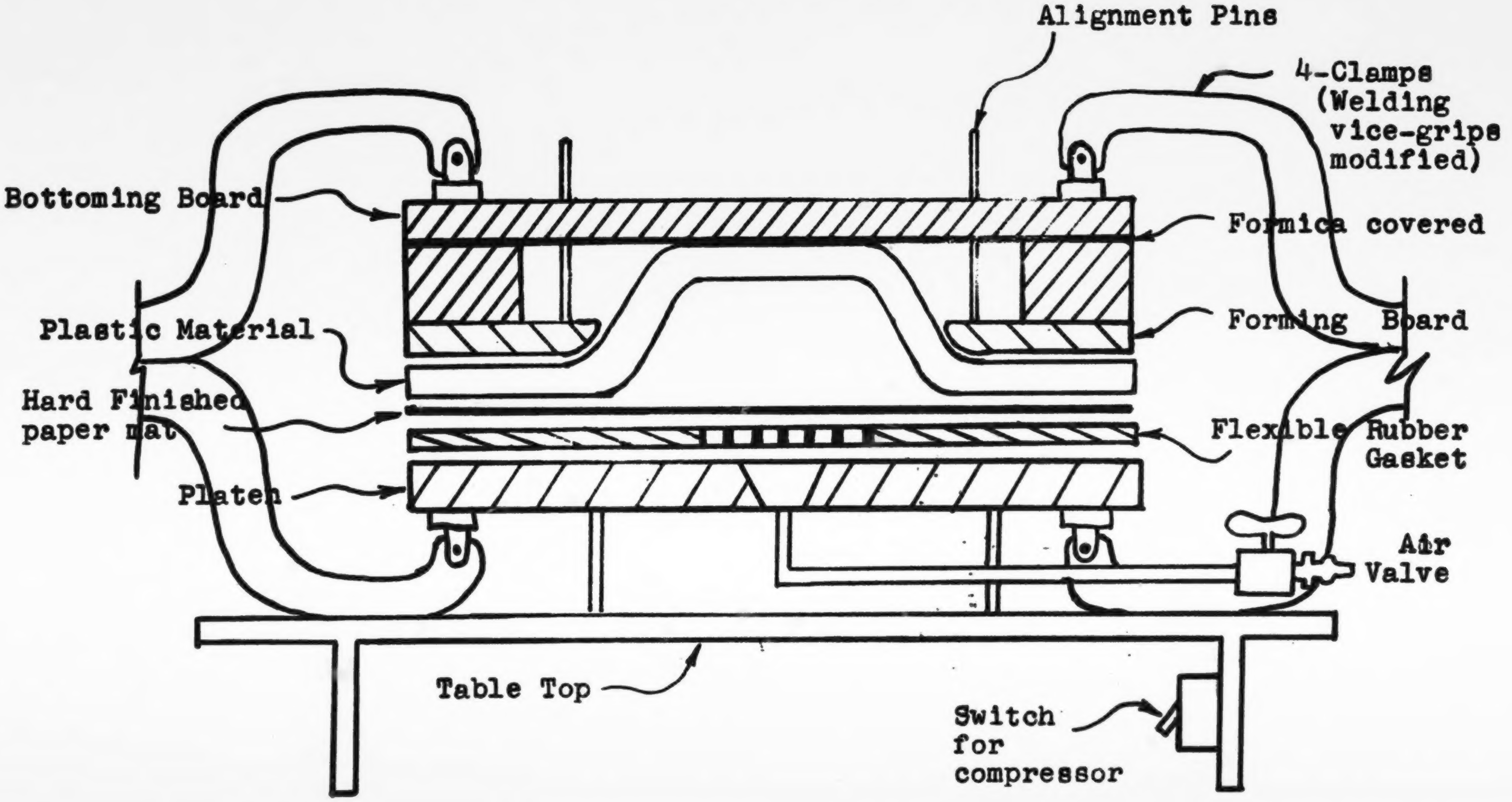
PROPERTIES OF THERMOPLASTICS

	ACETALS	ACRYLICS	CELLU-LOSICS	FLUORO-CARBONS	POLY-AMIDES	POLY-OLEFINS	STYRENES	VINYLS
Specific Gravity	1.4	1.17-1.20	1.15-1.40	2.1-2.2	1.09-1.14	.91-.97	.98-1.1	1.2-1.55
Tensile Strength (1000's psi)	10	7-14.5	1.9-8.5	6.5-9.9	7.0-11.0	1.5-5.5	3.5-12.0	1.5-9.0
Compressive Strength (1000's psi)	18	12-18	13-36	1.7-80.	7.2-13.0	2.5-10.	4.8-16.0	1.0-13.0
Impact Strength	Excelt	Excelt	Good	Excelt	Excelt	Excelt	Good	Good
Clarity	Tri-O	T-O	T-O	Tri-O	Tri-O	Tri-O	T-O	T-O
Electrical Resistance	Excelt	Good	Good	Excelt	Excelt	Excelt	Good	Good
Heat Distortion Point (Degrees F.)	338	150-210	115-250	250	300-360	105-230	165-225	100-165
Maximum Service Temp. (Degrees F.)	185-250	140-200	115-200	390-550	175-400	212-320	140-250	115-200
Burning Rate	S	S	S to SE	None	S to SE	S	S	S to SE
Water Absorption Rate	Low	Low	High	None	None	Low	None	Low
Effect of:								
Weak Acids	Attbysome	Little	Little	None	Little	Little	None	Little
Strong Acids	Attacked	Attbysome	Decomp.	None	Attacked	SlAttack	Attbysome	Attbysome
Weak Alkalies	Attbysome	Little	Little	None	None	Little	None	Little
Strong Alkalies	Attacked	Attbysome	Decomp.	None	None	Little	None	
Solvents	None	Solinsome	Solinmany	None	Little	Solinsome	Solins	
Outdoor Conditions (Sunlight)	Little "chalks"	None	Little	None	Slight	Crazes	Discolor	

T-transparent, Tri- translucent, O - Opaque S=slow, SE - self-extinguishing

AIR PRESSURE FORMING

SHOP MADE MACHINE


Alignment Pins
4-Clamps (Welding vice-grips modified)
Bottoming Board
Formica covered
Plastic Material
Forming Board
Hard Finished paper mat
Flexible Rubber Gasket
Platen
Air Valve
Table Top
Switch for compressor

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: Wayne A. Douglas
Central High School
Akron, Ohio

INSTRUCTIONAL LEVEL: High School - College

TITLE: Polymers: Cellular Plastics

PRESENTATION TIME: 2 periods

INTRODUCTION:

Cellular plastics, also referred to as expanded or foamed plastics, are growing members of the plastics of the plastics family. They are used in the making of insulation, as core materials for load-bearing structures, or cushioning materials used in product protection during shipping and for furniture, bedding and upholstering. Among those plastics which are commercially produced in cellular form are: cellulose acetate, epoxy, phenolic, polyethylene, polystyrene, silicone, urea-formaldehyde, urethane, and cellulose vinyl. (see transparency no. 1, no. 2 and no. 3)

OBJECTIVES:

1. To review the various types of cellular plastics used in industry.
2. To acquaint the students with the outstanding properties and characteristics of foaming materials.
3. To review the structural and chemical composition of cellular plastics.
4. To understand the production methods used in producing cellular plastics.
5. To demonstrate a few of the foaming processes.
6. To encourage the students to perhaps seek a "better way" and to always ask "why" when experimenting with a particular material.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Polymers

INTER-RELATION WITH OTHER SUBJECTS:

Chemistry - organic
Physics
Economics
Mathematics

USE IN INDUSTRY:

Commercially, cellular plastics can be produced in the form of slabs, blocks, sheets, molded shapes, extruded insulation and sprayed coatings. In addition, several can be "foamed in place" or "packed in place" in an existing cavity for potting of an electrical component within a housing, and for providing thermal insulation in a building or other structure.

Each of the nine major cellular plastics have specific industrial applications. However, the uses fall largely into the fields of thermal insulation, acoustical insulation, electrical insulation, potting, structural reinforcement, cushioning, floats, packaging, and displays. Transparency No. 1 will give a few specific industrial examples. (see transparency no. 3 and no. 9)

EDUCATIONAL MEDIA:

1. Charts
2. Overhead transparencies
3. Films

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT:

SAFETY:

In most cases the blowing agents release only the relatively harmless gas nitrogen, but in some cases other gases which may be toxic may be given off; also, it should be borne in mind that most blowing agents are highly flammable, and may be explosive if proper precautions are not observed.

The user should be thoroughly familiar with the chemical behavior of the blowing agents: (1) its activation temperature; (2) its liability to be activated by contact with other chemical; (3) its possible interaction with the material being expanded; (4) the rate at which it evolves gas; (5) the nature of its decomposition products.
For more detailed instruction in safety procedures consult Plastics Engineering Handbook, page 139.

PRESENTATION:

I. Classification of Family
    A. Specific Family:
        Various plastics are used in the making of foams, both thermosetting and thermoplastic. In general, the basic properties of the respective plastics are present in the foamed plastics, except, of course, those which are changed by the conversion to cellular structure.

B. Two General Types

The cellular plastics are of two general types regarding structure, the closed-cell type (in which each individual cell, more less spherical in shape, is completely closed in by a wall of plastic) and the open-cell type (in which individual cells are intercommunication).

II. Cellular Plastics

A. Chemical Types

The chemical types now in commercial manufacture number a total of nine. The major types are as follows:

a. cellulose acetate
b. epoxy
c. phenol-formaldehyde
d. polyethylene
e. polystyrene
f. silicone
g. urea-formaldehyde
h. urethane
i. vinyl

B.

Closed Cell	Open Cell
Cellulose Acetate	------
Epoxy	Epoxy
Polyethylene	------
Polystyrene	------
Silicone	------
Urea-formaldehyde	Urea-formaldehyde
Vinyl	Vinyl
Urethane	Urethane
Phenolic	------

(See transparency No. 2)

III. Structure and Composition

A. A cellular structure can be developed by several methods.

a. air is whipped into suspension or solution of the plastic, which is then hardened by heat or catalytic action or both.
b. a gas is dissolved in the mix and expands when pressure is reduced.
c. a liquid component of the mix is volatilized by heat.
d. water produced in an exothermic chemical reaction is volatilized within the mass by the heat of reaction.
e. carbon dioxide gas is produced within the mass by chemical reaction.

f. a gas, such as nitrogen, is liberated within the mass by thermal decomposition of a chemical blowing agent.

g. tiny beads of thermoset resin, hollow or expandable by heat, are incorporated in a plastic mix.

To determine whether a foam will be flexible, semi-rigid or rigid depends on the degree of crosslinking that takes place. The cross-linking triggered by the introduction of water is controlled in most cases by the molecular backbone which supplies the reactive sites. Thus, a resin which is characterized by a high degree of reaction sites will most likely produce a rigid foam.

B. Size of Cell:

The approximate size of the cell structure may vary from 0125 to 0.015 - in. diameter. This may vary with method of production.

C. Foaming Agents:

The cellular structure of many cellular plastics are developed by the release of gas within them. The substances used as the source of gas are called "blowing agents," or "forming agents." These are of two general types, both functioning under the influence of heat during the preparation of the cellular plastic.

a. Liquids which are volatilized without chemical change.

b. Chemicals which decompose to yield gaseous products.

Listed below are typical blowing agents:

a. Blowing action resulting from volatilization of water.

    isopropyl ether
    ethyl alcohol
    acetone
    fluorinated hydrocarbons

b. Blowing action resulting from decomposition.

    inorganic compounds
    ammonium nitrate
    sodium nitrate
    hydrazides (azide, terephthalamide, borohydrides)
    ammonium carbonate
    sodium bicarbonate
    nitroso compounds (N,N' - dinitroso-pents - Methylene tetramine)

The temperature of decomposition or activation of each blowing agent in uncompounded condition, in air, is so much influenced by chemical effects of the various resins, plasticizers, stabilizers, etc., that such data would be of very limited value in leading to even a preliminary choice of selected temperatures for specific blowing agents. For this reason, the advice of suppliers must be closely adhered to.

The following properties and behavior should be considered in choosing a chemical blowing agent:

a. it should release gas over a definite and short range of temperature.
b. the rate of release should be rapid, but controllable.
c. the gas, preferably, should not be corrosive or explosive; nitrogen is the preferred gas, but CO_2 is acceptable in some cases.
d. the blowing agent should disperse readily in the mix, and preferably should dissolve.
e. it should be stable in storage.
f. its residues should be colorless and nonstaining.
g. the blowing agent, and also its residues, should be nontoxic.
h. the decomposition of the blowing agent should not develop a large amount of exothermic heat.
i. the blowing agent, and its residues, should not affect the rate of cure of the plastic.
j. the blowing agent should function equally well in closed and open molds.
k. the blowing agent should be inexpensive,

The above mentioned list of blowing agents may tend to be rather confusing. At least it is on the part of the author, so a simplified chart below will attempt to clarify the type of blowing agent, and the resultant foam structure.

Foam Name	Blowing Agent	Structure
1. Cellulose Acetate	Super heated solvent, inert material (solvent) provides nuclei for volatilization	rigid structure
2. Epoxy	Polystyrene beads - exothermic reaction and endothermic reaction	rigid structure

3. Phenolic	Reaction between phenol and formaldehyde, exothermic reaction causes liberation of gas	rigid structure
4. Polyethylene 5. Polystyrene	heat liberates inert gas--free-flowing beads heated, beads expand and "puff," some pre-heated or pre-expanded--this is used where density is not critical.	flexible structure; rigid structure
6. Silicone	blowing agent decomposes into nitrogen gas--another 2 silicone components plus catalyst=hydrogen gas--exothermic heat	rigid & flexible structure
7. Urea-formaldehyde	mechanical mixing of air plus heat to cure resin	rigid structure
8. Urethane	two types--mixing polyols with a diisocyanate and water. Reaction between isocyanate group and water--involves volatilization of blowing agent causing exothermic heat	flexible & rigid structure
9. Cellular Vinyls	mechanical blowing (a plastisol plus carbon dioxide gas) plus heat. Plastisol plus blowing agent which decomposes.	flexible & rigid structure

(See transparency No. 2)

IV. Properties

The outstanding properties of cellular plastics are very wide and varied. To say that all have the same definite properties would be most incorrect; however, one might make some general statements about their properties. The student will need to review the individual property charts of each cellular plastic for additional and specific information. Several transparencies No. 5,6,7,8, are provided for review.

A. Properties - General:
   a. Cellulose acetate
      smooth dense skin, does not tend to become brittle or frangible, tolerate temperature up to 350° F., good mechanical properties between -70° F. and 77° F.
   b. Epoxy
      can be "pack in place" or "foam in place," high compression strength 600 psi, flame retardent formulation are available, long shelf life, resistant to alkalies, most acid, and solvents, dielectric properties range from 2-7, heat stability up to 600° F.
   c. Phenolic
      very light weight, high degree of flame retardance, outstanding thermal insulation properties, good acoustical properties, low flexual strengths and thermal expansion, absorbs water rapidly, good "foaming in place" characteristics.
   d. Polyethylene
      very low dielectric constant, good electrical insultaion, low density, good moisture resistance.
   e. Polystyrene
      very light in weight, used at relatively low temperatures, good low-temperature insulation, good buoyancy characteristics, low thermal conductivity and water resistance, good packaging properties.
   f. Silicone
      good vibration insulation, foamed in place, thermal insulation, and cushioning around electrical components.
   g. Urea-formaldehyde
      good for floral displays and in thermal insulation, poor water adsorption characteristics, won't support combustion, in non-corrosive and nontoxic, poor thermal linear stability, 130° results in shrinkage.
   h. Urethane
      good foaming in place characteristics, good thermal insulation, good for high density application, stable at high temperatures, resistant to vibration and moisture, available in fire-retarding formulations.

i. Vinyl
good buoyancy properties, good high density properties for electrical insulation, good resilience and flexural characteristics, nonflammability, low tendency to absorb plasticizers from primary insulation, low in weight.

V. Industrial Production Processes

Two principal processes of foaming are molding expandable polystyrene and casting polyurethane. Many variations are used for other plastic foams, but these two account for a large part of the foam produced and are typical of the processes used.

A. Expandable beads

The styrene beads are pre-heated or expanded to the desired density (usually from one to twenty pounds per cubic foot). The pre-expanded beads are loaded into a closed mold cavity by air pressure. The mold is heated to about 275° F. to expand and fuse the beads. Direct heat in the form of live steam is also forced through small holes in the mold. After expansion, the mold and part are cooled to prevent further expansion and resultant distortion. This cooling is done by circulating cold water around the molds. The mold is opened and the molded parts are ejected by forcing air or water through the steam holes in the mold.

Equipment for experimental or short-run production may be simply a steam probe which is inserted in the mold, a steam autoclave (pressure cooker) into which the entire mold is placed, or a jacketed mold around which steam is circulated.

B. Casting urethane foam

This process consists of mixing the resin and the foaming agent in proper proportions, changing them into a closed mold, allowing them to foam and fill the recesses of the mold, sometimes aiding the curing action with heat, and opening the mold and ejecting the finished part.

In some applications, the plastic is foamed in place. One such application is for flotation compartments in boats. The plastic is placed into a compartment in the boat and allowed to foam and fill the void. It adheres to the walls of the cavity providing support as well as buoyancy. (See transparency No. 4)

EDUCATIONAL FILMS:

1. Born of Foam
   Sinclair-Coppers Co., Koopers Bldg., Pittsburg, Penn. 15219.
2. Christmas Carrolls
   Association Films, Inc., 347 Madison Ave., New York, New York 10017.
3. Dabco One-shot Urethane Catalyst
   Houdry Process & Chemical Co., Urethane Chemicals Dept.
   1528 Walnut St., Philadelphia, Pennsylvania.
4. Fabrication Machinery for Flexible and Rigid Foams
   Falls Engineering & Machine Co., Sales Dept., 1734 Front
   St., Cuyahoga Falls, Ohio.
5. Facts about Foam
   The Dow Chemical Co., Midland, Michigan.
6. Foamagic for Homemakers
   Mobay Chemical Co., Advertising Dept., Penn Lincoln Parkway West, Pittsburgh, Penn. 15205.
7. Focus on Foam
   The Dow Chemical Co., Visual Aids Dept., Midland, Michigan 48640.
8. Form and Formula
   The Society of the Plastics Industry, Inc., 250 Park Avenue, New York, N. Y. 10017.
9. Furs to Feathers to Foam
   Mobay Chemical Co., Penn Lincoln Parkway West, Pittsburgh, Penn. 15205.
10. Magic Molecule
    The Society of the Plastics Industry, Inc., 250 Park Ave., New York, N. Y. 10017.
11. Manufacture of Plastics
    The Society of the Plastics Industry, Inc., 250 Park Ave., New York, N. Y. 10017.
12. A New World of Chemistry
    Reichhold Chemicals, Inc., Advertising Dept., 525 North
    Broadway, White Plains, New York 10602.
13. Physical Chemistry of Polymers
    Bell Telephone Laboratories, Inc., Murray Hill, New Jersey.
14. Plastics, Industrial Processes and Products
    Stout State College, Audio-Visual Center, Menomonie, Wis.
15. Talking Plastics
    The Society of the Plastics Industry, Inc., 250 Park Ave., New York, N.Y. 10017.
16. What Can the Matter Be?
    American Cyanamid Co., Public Relations Div., Wayne, New Jersey.

DEFINITION TERMS:

1. Autoclave Molding - Modification of the pressure bag method for molding reinforced plastics. After lay-up, entire assembly is placed in steam autoclave at 50-100 psi.
2. Cellulose Acetate - An acetic acid ester of cellulose. It is obtained by the action, under rigidly controlled conditions, of acetic acid and acetic anhydride on purified cellulose usually obtained from cotton linters.
3. Exotherm - (1) The temperature/time curve of a chemical reaction giving off heat, particularly the polymerization of casing resins. (2) The amount of heat given off. The term has not been standardized with respect to sample size, ambient temperature, degree of mixing, etc.
4. Foamed Plastics - Resins in sponge form. The sponge may be flexible or rigid, the cells closed or interconnected, the density anything from that of the solid parent down to, in some cases, 2 lb/per cu. foot. Compressive strength of rigid foams is stable enough to make it useful as core materials for sandwich structures.
5. Foaming Agents - Chemicals added to plastics and rubbers that generate inert gases on heating, causing the resin to assume a cellular structure.
6. Foam-in-place - Refers to the deposition of foams which requires that the foaming machine be brought to the work which is "in place" as opposed to bringing the work to the foaming machine.
7. Isocyanate Resins - Most applications for this resin are based on its combination with polyols, polyesters, polyethers, etc. During this reaction, the reactants are joined through the formation of the urethane linkage - and hence this field of technology is generally known as urethane chemistry.
8. One Shot Molding - In the urethane foam field, indicates a system whereby the isocyanate, polyol, catalyst, and other additives are mixed together directly and a foam is produced immediately.
9. Radio Frequency Preheating - A method of preheating used for molding materials to facilitate the molding operation or reduce the molding cycle.
10. Rigin Resins - One having a modulus high enough to be of practical importance, 10,000 psi or greater.
11. Steam Molding - Used to mold parts from pre-expanded beads of polystyrene using steam as a source of heat to expand the blowing agent in the material.

12. Thermal Conductivity - Ability of a material to conduct heat; physical constant for quantity of heat that passes through unit cube of a substance in unit of time when difference in temperature of two faces is 1°.
13. Urea Formaldehyde - A synthetic resin from the reaction of area with formaldehyde or its polymers.

REFERENCES:

STUDENT:

1. Modern Plastics Encyclopedia, *Modern Plastics*, Vol. 43, No. 1A, 1965.

2. Phillips Petroleum Co., *Glossary of Plastics Terms*, 3rd Edition.

3. "Plastics Reference Issue," *Machine Design*, Vol. 38, No. 14, New York: The Penton Publishing Co., 1966.

TEACHER:

1. American Society for Testing Materials, ASTM Standards on Plastics, Philadelphia: American Society for Testing Materials.

2. Randolph, Alan F., *Plastics Engineering Handbook*, New York: Reinhold Publishing Corp., 1960.

3. "Materials," *Scientific American*, San Francisco, Witt, Freeman and Company, 1967.

4. Parkyn, Brian and Clifton, B.V., *Polyesters*, New York: American Elsevier Publishing Co., Inc., 1967.

5. Teach, William C. and Riessling, Georg C., *Polystyrene*, New York: Reinhold Publishing Corp., 1960.

6. Dombrow, Bernard A. *Polyurethanes*, New York: Reinhold Publishing Corp., 1965.

The plastics industry in 1967

Synthetic resins and cellulosics production and sales, 1967

Market	Production million lb.	Sales million lb.
Alkyd	588	300
Cellulosics	180	167
Coumarone-indene and petroleum resins	276	275
Epoxy	139	137
Phenolic	1,000	789
Polyester	480	443
Polyethylene, high density	1,100	1,032
Polyethylene, low density	2,800	2,600
Polypropylene	645	641
Polystyrene and styrene copolymers	2,480	2,400
Polyvinyl chloride and copolymers	2,200	2,167
All other vinyls	516	480
Urea and melamine	642	559
Miscellaneous[a]	1,120	1,110
Total	**14,166**	**13,100**

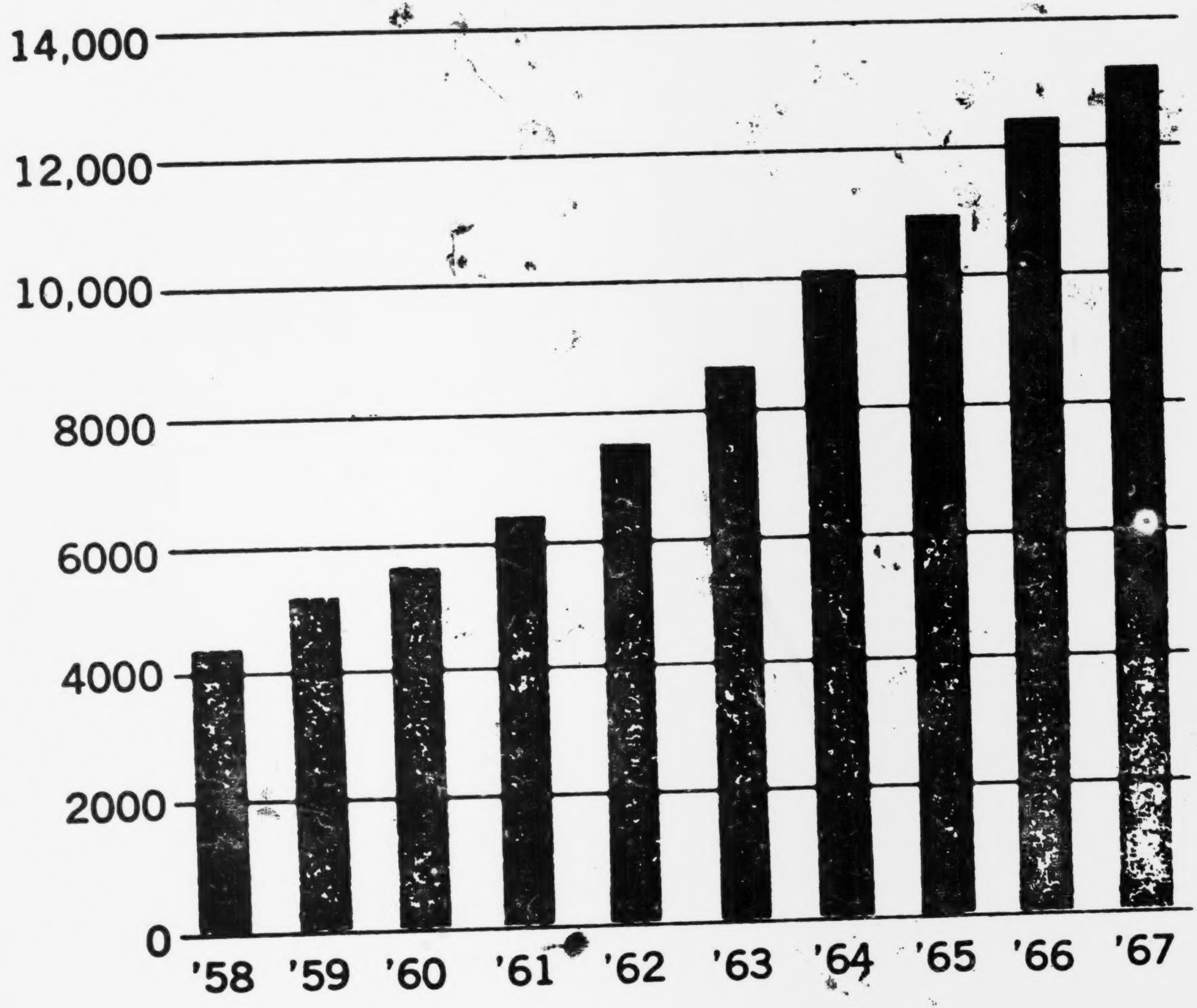
a—Includes acetal, acrylic, fluoroplastics, nylon, phenoxies, polycarbonate, silicones, urethane foam, and others.

TABLE OF PLASTIC FOAMS

Foam Name	History	Foaming Agent	How Foamed	Components	Open/ Closed	Rigid/ Flex.	*Fabrication**			Application	Toxic
							FIP	Mold	Ext.		
CELLULOSE ACETATE	WW II ships-planes	Super heated solvent	Extruded	CA solvent	C	R			X	Structurals insulation panels Flotation	
EPOXIES (special equip. necessary)	1949 - Encapsulate Elect. parts	Polystrene Beads	Endothermic heat Exothermic heat	Epoxy - Catalyst exp. beads	O C	R	X	X	X	Insulation Electrical Acoustical Thermal	
PHENOLIC (special equip. necessary)	1945 - U. S.	Reaction between Phenol Formaldehyde or Hollow beads	Liberation of gas	Phenol Formaldehyde or Hollow beads Polyester Resin	C	R	X	X	X	Insulation Thermal Acoustical Electrical	X
POLYETHYLENE (special equip. necessary)	1944 wire insulation	Thermal Liberates inert gas	Extruded	Polyethylene Nitrogen gas	C	F	X		X	Wire Insulation	
POLYSTYRENE (may be used in school shop)	1952 Germany 1954 U. S.	Gas Heat Pressure	Extruded	Polystyrene Nitrogen gas	C	R	X	X	X	Packaging Flotation	
SILICONES (special equip. necessary)	1950 U. S.	Nitrogen when heated	Liberation of Nitrogen	Blowing agent Silicon catalyst	C	R F	X	X	X	Insulation Thermal Acoustical Electrical	
URETHANE (may be mixed by hand)	1930's Germany	Water and amine	Liberation of gas	B. agent Polyoly Isocyanate Water	O C	F R	X	X	X	Insulation Flotation Packaging Upholstery	X some
UREA - FORMALDEHYDE (special equip. necessary)	WW II Germany	Mechanical whipping of air, Hollow spheres are added to mix			O C	R	X	X	X	Thermal insulation Floral displays	
CELLULAR VINYLS (special equip. necessary)	WW II Germany	Mechanical Blowing			C C	F R	X	X	X		

*FIP - Foam in Place **Ext. - Extrude

Ten-year production record (million lb.)

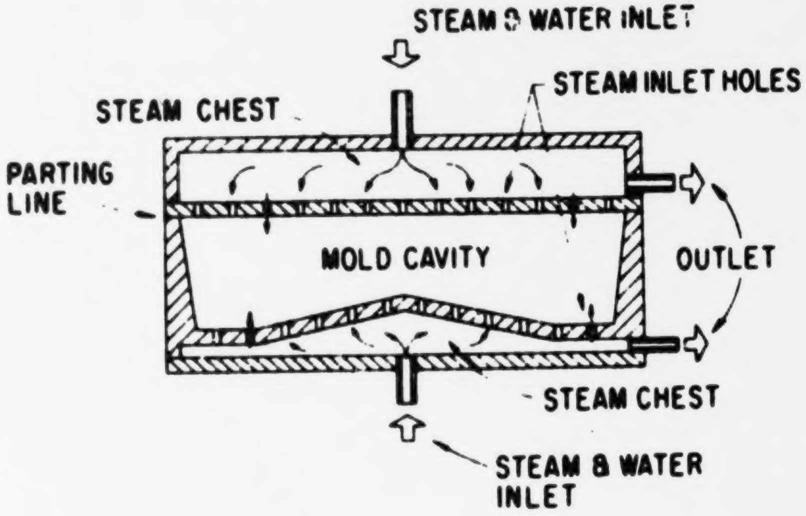


URETHANE FOAM

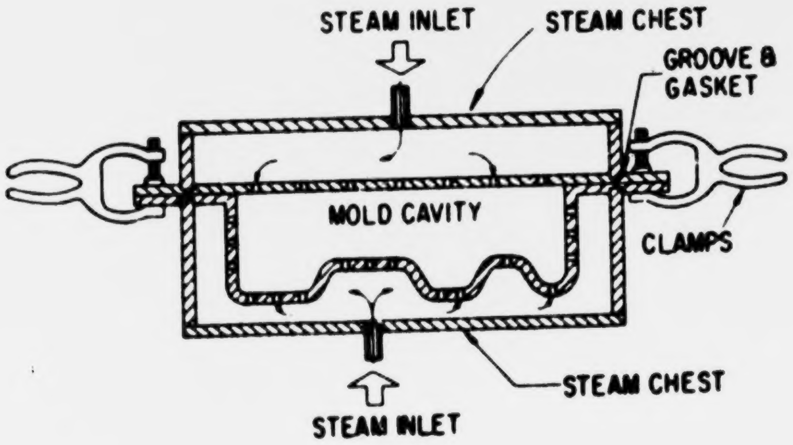
Pattern of consumption

Market	1966 million lb.	1967 million lb.
Flexible foam		
Bedding	45	50
Furniture	110	135
Packaging	7	8
Rug and underlay	9	10
Textile laminates	40	45
Transportation	80	110
Miscellaneous	39	32
Total	**330**	**390**
Rigid foam		
Appliances	30	33
Building	24	30
Industrial tanks	4	5
Marine flotation	7	13
Mine tunnel seals	2	2
Packaging	4	5
Transportation	33	33
Miscellaneous	2	9
Total	**106**	**130**

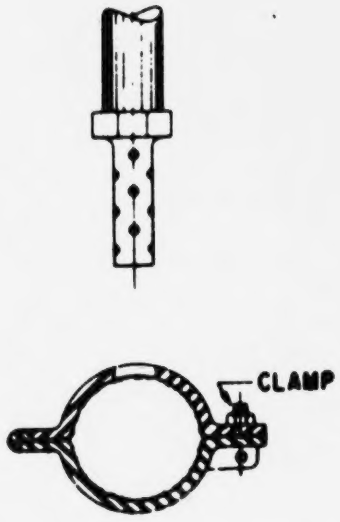
Steam Chest Mold


STEAM & WATER INLET
STEAM INLET HOLES
STEAM CHEST
PARTING LINE
MOLD CAVITY
OUTLET
STEAM CHEST
STEAM & WATER INLET

Removable Cavity Mold


STEAM INLET
STEAM CHEST
GROOVE & GASKET
MOLD CAVITY
CLAMPS
STEAM CHEST
STEAM INLET

STEAM PROBE MOLD



ourtesy of The Dow Chemical Company

Table 1—Typical Properties of Flexible Urethane Foam (ASTM D1564)

	Foam Type	
	Polyether	Polyester
Density (lb per cu ft)	1.1-2.3	1.6-2.0
Tensile Strength (psi)	9-22	25-33
Ultimate Elongation (percent)	222-310	250-500
Tear Strength (lb per linear in.)	2-4	2.3-4.2
Indentation Load Deflection 4-in. thick sample, Method A (lb per 50 sq in.)		
at 25% compr.	9-45	—
at 50%	12-60	—
at 65%	16-85	—
at 75%	25-150	—
Compression Deflection (psi)		
at 25% compr.	0.15-0.6	0.46-0.48
at 50%	0.2-0.7	0.56-0.80
at 75%	0.4-1.6	1.29-2.09
Compression Set, 158 F, Method B (percent)		
at 50% compr., 22 hr	3-4	3.5-6.0
at 90% compr., 22 hr	6-8	8-20

Table 2—Typical Properties of Rigid Polyether and Polyester Urethane Foams

Density (lb/cu ft) ASTM D1622	1.5 to 2.0
Tensile Strength (psi) ASTM D1623	30 to 40
Compression Strength at Yield (psi) ASTM D 1621	
parallel to foam rise	20 to 45
perpendicular to foam rise	10 to 25
Compression at Yield (percent)	5 to 10
Closed Cells (percent) ASTM D1940	92 to 98
Moisture Vapor Permeability ASTM C 355	
wet cup (perm/in.)	2 to 8
Dimensional Stability (percent volume change)	
at 70 C, 100% RH, 2 wk	7 to 15
at 100 C, 2 wk	5 to 10
at —40 C, 2 wk	0 to 2

Table 4—Electrical Properties of Urethane Foams

	Foam Type						
	Polyether	Polyester			Castor Oil		
Density (lb per cu ft) →	–	2	5	16.5	2.2	5.5	16.2
Dielectric Constant, 10^3 cps	1.06	1.27	1.44	1.56	1.66	1.77	2.10
Power Factor, 10^3 cps	–	0.0057	0.0055	0.0051	0.0043	0.0049	0.0043
Dielectric Strength (v per mil)	–	38	40	42	33	44	48
Dissipation Factor	0.0003	–	–	–	–	–	–

TABLE I: Amount of resin used in polystyrene foam[a]

Type of foam	1965	1966	1971	1975
	million lb.			
Expanded PS board	40	42	52	60
Expandable PS beads	100	125	250	450
Foamed PS sheet (from crystal)	10	20	80	175
Total	**150**	**187**	**382**	**685**
% of polystyrene resin market	**9.3**	**10.2**	**12.1**	**14.1**

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a—Figures for 1965 and 1966 shown in Jan. MPl, p. 120, have been revised on basis of latest statistical data and redistribution of "miscellaneous" category.

TABLE II: The markets for expandable polystyrene

	million lb.		
	1966	1971	1975
Construction and flotation	43	70	95
Packaging	26	90	175
Cups	28	40	70
Housewares and toys	21	30	65
Miscellaneous	7	20	45
Total	**125**	**250**	**450**

PROPERTIES OF THERMOSETS

	AMINOS	CASEIN	EPOXIES	PHENOLICS	POLYESTERS	SILICONES	URETHANES
Specific Gravity	1.47-1.55	1.35	1.11-1.8	1.25-1.55	1.3	1.6-2.0	1.15-1.20
Tensile Strength (1000's psi)	5.0-13.0	10.0	4.0-9.0	4.0-9.0	4.5-25.0	4.0-35.0	Varies with rigid and flexible
Compressive Strength (1000's psi)	25-45	27-53	13-28	15-50	12-34	9-15	
Impact Strength	Good	Fair	Ex.ifRei.	Good	Ex.ifRef.	Good	
Clarity	Tri-0	T-0	T-0	Tri-0	T-0	0	0
Electrical Resistance	Good (low freq.)	Fair	Excell.	Good	Good (lo Frq)	Excell.	Good
Heat Distortion Point (Degrees F.)	266-400	300	250-290	150-260	140-425	500-900	does not apply
Maximum Service Temp. (Degrees F.)	210-400	275	200-300	160-300	250-350	450	400
Burning Rate	None(SE)	S	S to SE	Sto none	S to SE	Sto none	S to SE
Water Absorption Rate	Low	High	Very low	Low	Low	Very low	Very low
Effect of:							
Weak Acids	Little	Little	None	Little	Little	Little	Little
Strong Acids	Decomp.	Decomp.	Att.Few	Attacked	Attacked	Little	Little
Weak Alkalies	Little	Decomp.	None	None	Attbysome	Little	Little
Strong Alkalies	Att.some	Decomp.	Little	Decomp.	Attacked	Little	Little
Solvents	None	Little	Little	Little	Attbysome	Attbysome	Little
Outdoor Conditions (Sunlight)	Discolor	Discolor	None	Discolor	Discolor	Little	Discolor on some

T - transparent, Tri - Translucent, O - Opaque S-slow, SE - self-extinguishing

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: L. Russell Pickett
Hamlin Junior High School
Springfield, Oregon

INSTRUCTIONAL LEVEL: Jr. High, Sr. High, Jr. College

TITLE: Polymers - Cellulosics

PRESENTATION TIME: Lecture-Demonstration 3 - 8 hours, Student Experiments & Project work 6 - 14 hours.

INTRODUCTION:

Cellulosics are thermoplasticspolymers prepared by various treatments of purified cotton linters or special grades of wood cellulose. Cellulosics are among the toughest of plastics. Rough use will not break cellulose parts, but abrasives will scar their surface. There are more than one type of cellulose polymer, but this unit will study only cellulose acetate. Many consumer items that we purchase are easier to handle, more attractive, cleaner and healthier when this material is used for packaging. It is also used for optical frames and pen barrels.

OBJECTIVES:

1. To acquaint the students with this plastic material as one in the large family of thermoplastics.
2. The students should be able to use this material correctly for their best specific physical properties in production of products.
3. The students should become familiar with this material as it is seen and effectively used in our society today.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Polymers (plastics)

INTER-RELATION WITH OTHER SUBJECTS:

1. Wood - Metal - General Shop
2. Lecture in Science Department, Lab. in IA lab.
3. Use of science lab for chemical theory demonstrations

USE IN INDUSTRY:

The four prominent industrial cellulosics are: cellulose acetate, celluslose acetate butyrate, cellulose propionate, and ethyl cellulose. Mos of this cellolosic material are formed and fabricated industrially in the following manner: injection molding, blow molding, extruding, film casting and thermoforming by the vacuum forming process. The cellulosic material we are interested in is cellulose acetates, which are often used when toughness, permanence, flame resistance and transparency are required at a moderate cost. Extruded cellulose acetate film and sheet are used for packaging and thermoforming. Extruded rod stock is used for tool handles and machine parts. Extruded profiles are used for trim and wear strips on furniture. Other large volume products made by injection molding include pen barrels and caps, tool handles, brush backs, jewelry, hair ornaments, toys and dolls. Flame-resistant and self-extinguishing forms are used in small appliance housings and various electrical applications. Cellulose acetate is available in pellets in injection molding, extrusion and blow molding. Many types and sizes of sheet and film are available, as well as rod, pipe and tubing. The three basic types of cellulose acetate are: (1) Medium properties adequate for average use - good fabrication qualities; (2) Hard Superior heat resistance; and (3) soft, good toughness.

MATERIALS AND EQUIPMENT:
vacuum forming machine
injection molding machine
extruding machine } if available
blow molding machine
solvents: incl. acetone, methyl-ethyl ketone, alcohol, benzene,
    bensyl alcohol, and cyclohexene.
adhesives: incl. ethylene dichloride, polyvinyl chloride,
    cellulose nitrate, 20% ethyl alcohol & 80% toluene and 5%
    ethyl cellulose, 17.5% ethyl alcohol, and 77.5% toluene.
heat gun
thermostat controlled oven
whitney junior punch
clothes iron, with temperature control
electric soldering gun or wood burning pen
variable transformer
commercial heat sealer if available
silicon spray (mold release)
six spring clamps (sm. or med. size)
as many samples of plastics and commercial materials as possible
4 or 5 packaging samples
bunsen burner
6 doz. pint & half-pint glass jars (wide mouth)
acid swaps
eye droppers (one dozen)
aerosol spray paint cans - assorted colors

EDUCATIONAL MEDIA:

1. Films:
   PLASTICS: INDUSTRIAL PROCESSES AND PRODUCTS
   ORIGIN AND SYNTHISES OF PLASTIC MATERIALS
   BUTYRATE PEELABLE PLASTIC PACKAGING
   HALF SECOND BUTYRATE - A PROTECTIVE COATING FOR EXTERIOR ALUMINUM SURFACES
   MODERN METHODS OF MAKING & APPLYING PLASTIC FILM
   SHAPE OF PLASTICS
2. Transparencies:
   #1 - #15 - attached at end of unit
3. Single concept film list - super 8 mm silent
   1. Operation of Vacuum Forming Machine
   2. Operation of Extrusion Molding Machine
   3. Operation of Injection Molding Machine
4. Audio-Visual Materials
   1. Overhead projector
2. 2. 8mm Single concept projector
   3. Safety charts on cutting and punching with hand tools
   4. Chart on the commercial production of Cellulose Acetate
   5. Molecular Models
   6. Chart on the replacement of punches and dies in the Whitney Junior Punch
   7. Chart on the Operation of the Vacuum Former
   8. Chart on the Operation of the Extrucion Molding Machine
   9. Chart on Parts of this machine and operational procedures.
   10. Heat-Sealing Temperature Ranges for Plastic Films Chart.

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT:

SAFETY:

1. This sheets of this material burn quite easily
2. Many of the solvents used will act as acids on clothes and skin.

PRESENTATION: (instructor)

A. Introduction to polymers (plastics) - Transparencies 1, 2, 3; samples of various kinds of plastics used in the home, Film 1.

B. Atoms & Molecular Structure of Polymers - Trans. 4, 5, 6, Molecular Models, Film 2.
C. Polymerization - Trans 7.
D. Natural Polymers - Trans. 8, 9, Molecular Models.
E. Thermoplastic family - Trans. 10, Film 3.
F. Cellulosic Structure - Trans. 11, Molecular Models.
G. Producing Cellulose Acetate - Chart, Trans. 12, Film 4.
H. Properties of Cellulose Acetate - Demonstration on tearing film, Trans. 13, 14, Films 5 & 6.
I. Heat Sealing - Demonstration
J. Thermoforming - Demo., Trans. 15.
K. Adhesion - Demo. on the various warp and adhesives used, Traas. 13.
L. Solvents - Demo., Trans 13
M. Cutting, shaping, texturing - Demo: cutting, bending without heat and texturing with a vacuum former on film material, punching holes in film with Whitney Jr. Punch, Charts on Safe Operation of cutting tools, Single Concept film on Operation of the Vacuum forming, Chart on replacing of various sizes of dies and punches.
N. Fabrication:
   1. Vacuum Forming - Demo. on machine, Chart on operation, Single concept film.
   2. Extrusion Molding Machine - Demo. on machine, Cutting operation single concept film on the operation of the machine.
   3. Injection Molding Machine - Demo. on a machine, Chart on Parts of this machine and Operational Procedures, Single Concept film on the operation.

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE: (questions to be answered)

1. Name some heat sealable plastics
2. Name three methods of heating sheets and films for heat sealing
3. What is the burning rate of cellulose acetate?
4. What is the impact strength of cellulose acetate?
5. What solvent effects this material the fastest?
6. What type of classification of plastic may be heat sealed?
7. Is nitro cellulose a heat sealable plastic?
8. Which adhesive works the best on this material?

9. Why does this plastic material seek its original shape when reheated after forming?
10. How do plastic materials differ in molecular structure?

DEFINITION OF TERMS:

1. Amorphous phase - devoid of crystallinity - no definite order. At processing temperature,the plastic is normally in the amorphous state.
2. Burning rate - the tendency of plastic articles to burn at given temperatures. Certain plastics, such as those based on shellac, burn readily at comparatively low temperatures. Others will melt or disintegrate without actually burning, or will burn only if exposed to direct flame. These latter are often referred to as self-extinguishing.
3. Celluloid - thermoplastic material made by the intimate blending of cellulose nitrate with camphor. Alcohol is normally employed as a volatile solvent to assist plasticizing, and is subsequently removed.
4. Cellulose Acetate - acetic acid ester of cellulose. Obtained by the action under rigidly controlled conditions, of acetic acid and acetic anhydride on purified cellulose usually obtained from cotton linters. All three available hydroxyl groups in each glucose unit of the cellulose can be acetylated but in the material normally used for plastics it is usual to acetylate fully and then to lower the acetyl value (expressed as acetic acid) to 52-56% by partial hydrolysis. When compounded with suitable plasticizers it gives a tough thermoplastic material.
5. Degree of polymerization - the number of structural units or mers in the "average" polymer molecule in a particular sample. In most plastics the DP must reach several thousand if worthwhile physical properties are to be had.
6. Extrusion - compacting of a plastic material and the forcing of it through an orifice in more or less continuous fashion.
7. Pulp - form of cellulose obtained from wood or other vegetable matter by prolonged cooking with chemicals

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TEACHER:

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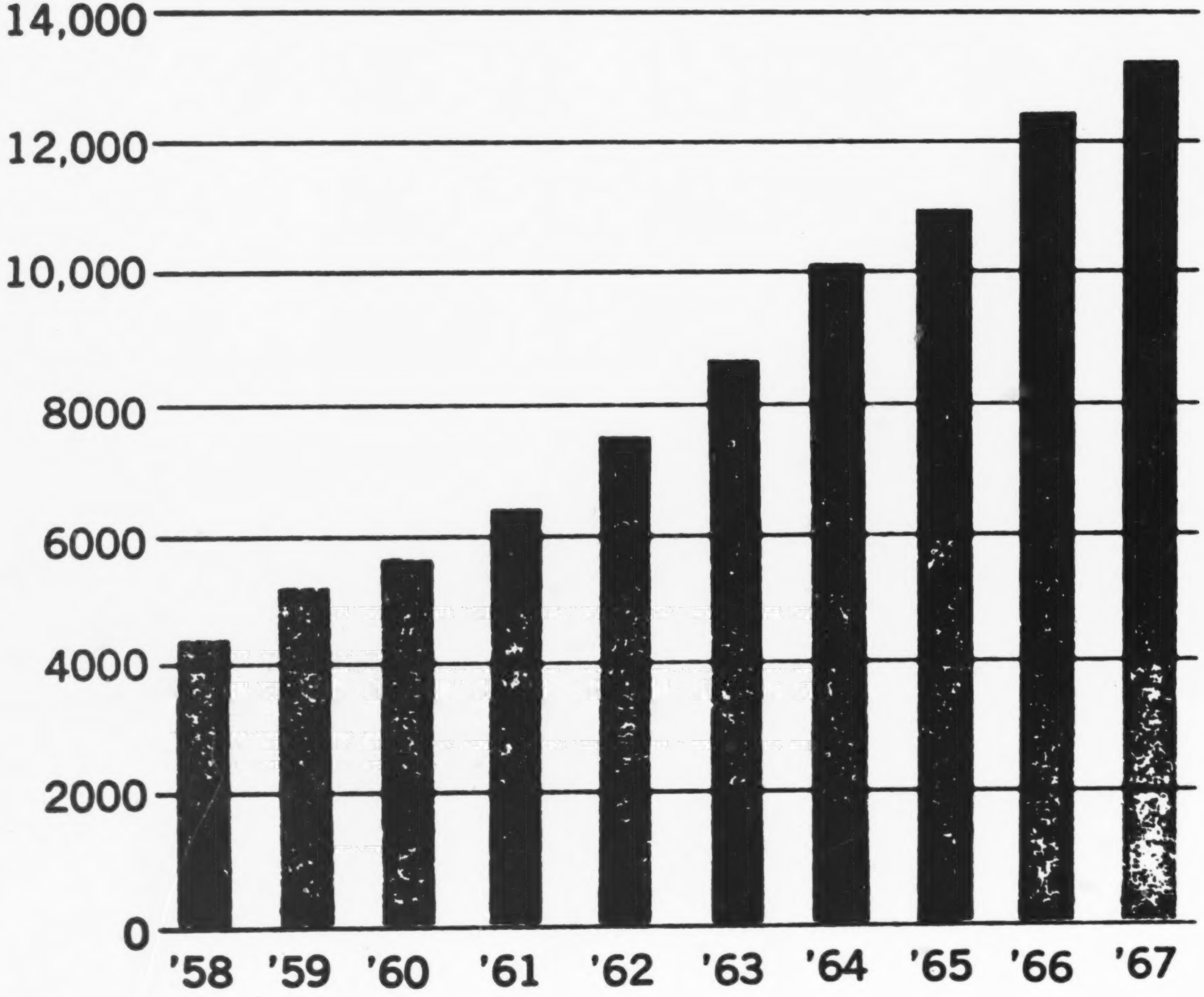
The plastics industry in 1967

Synthetic resins and cellulosics production and sales, 1967

Market	Production million lb.	Sales million lb.
Alkyd	588	300
Cellulosics	180	167
Coumarone-indene and petroleum resins	276	275
Epoxy	139	137
Phenolic	1,000	789
Polyester	480	443
Polyethylene, high density	1,100	1,032
Polyethylene, low density	2,800	2,600
Polypropylene	645	641
Polystyrene and styrene copolymers	2,480	2,400
Polyvinyl chloride and copolymers	2,200	2,167
All other vinyls	516	480
Urea and melamine	642	559
Miscellaneous[a]	1,120	1,110
Total	**14,166**	**13,100**

a—Includes acetal, acrylic, fluoroplastics, nylon, phenoxies, polycarbonate, silicones, urethane foam, and others.

Ten-year production record (million lb.)

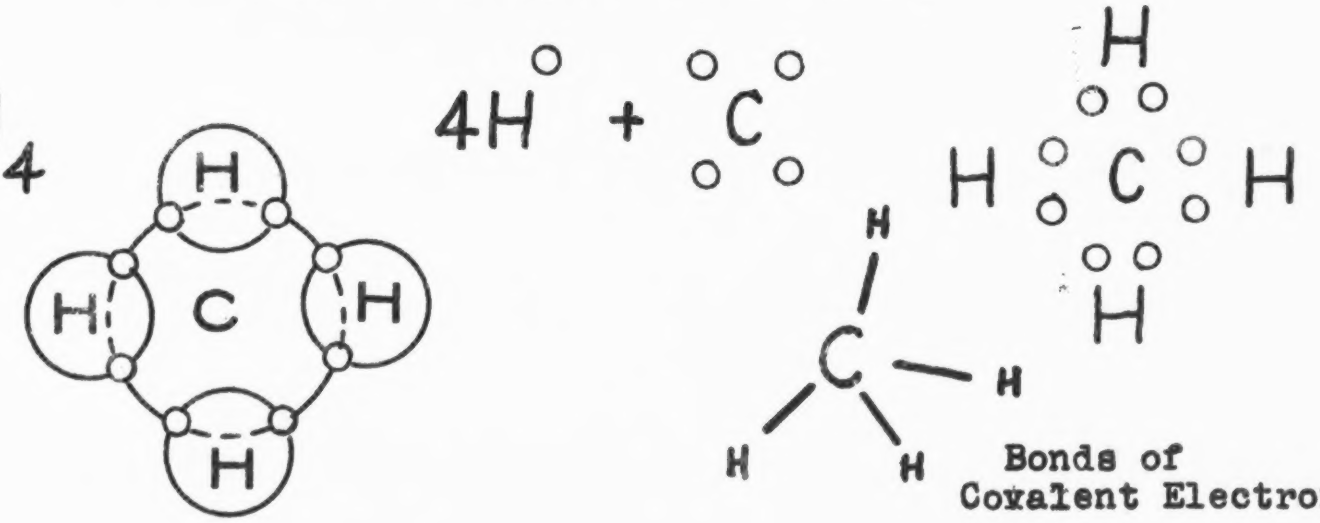


COVALENT BONDS

COMPOUNDS

Methane (Marsh Gas)

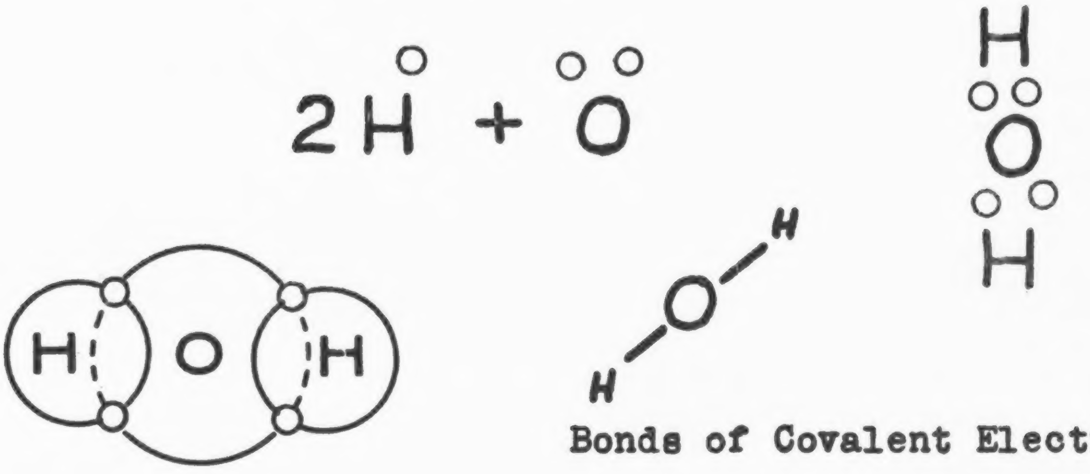
CH_4



Bonds of Covalent Electrons

Water

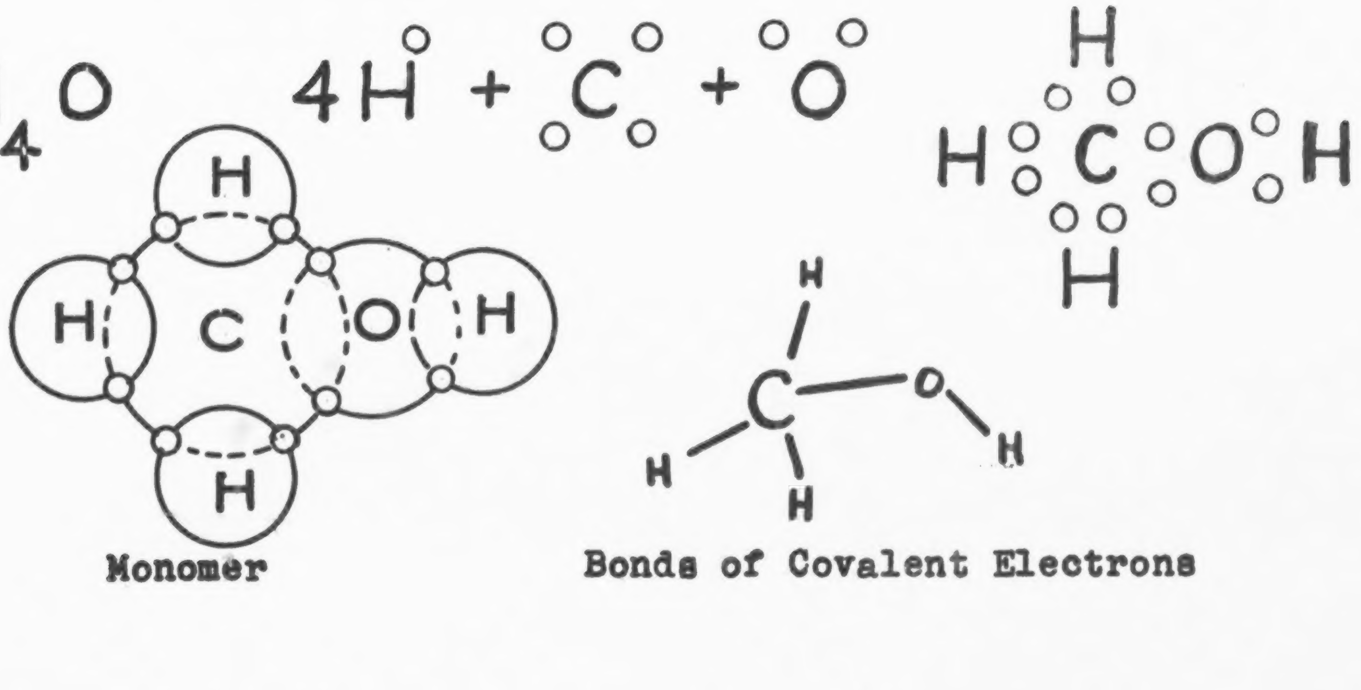
H_2O



Bonds of Covalent Electrons

Methyl Alcohol

CH_4O



Monomer

Bonds of Covalent Electrons

Formulas, Atoms & Structures

FORMULAS

1. **Molecular** — Indicate kind and number of atoms in molecule.

2. **Structural** — Also indicate chemical bonds between atoms.

Water

H_2O

Two atoms of hydrogen

One atom of oxygen

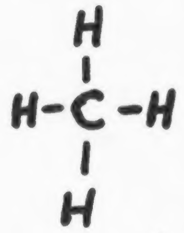
$H-O-H$

Methane (Marsh Gas)

CH_4

Four atoms of hydrogen

One atom of carbon



$H-\overset{H}{\underset{H}{C}}-H$

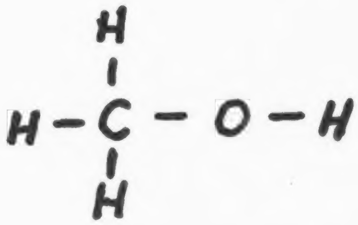
Methyl Alcohol

CH_4O

Four atoms of hydrogen

One atom of carbon

One atom of oxygen



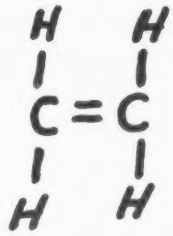
$H-\overset{H}{\underset{H}{C}}-O-H$

Ethylene

C_2H_4

Four atoms of hydrogen

Two atoms of carbon



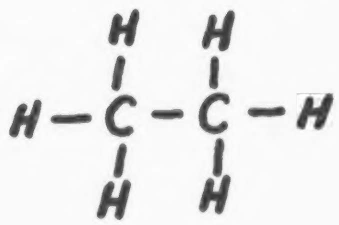
$\overset{H}{\underset{H}{C}}=\overset{H}{\underset{H}{C}}$

Ethane

C_2H_6

Six atoms of hydrogen

Two atoms of carbon



$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-H$

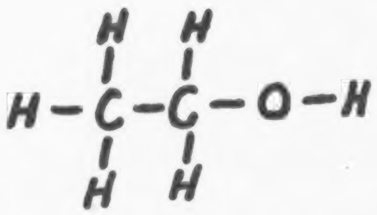
Ethyl Alcohol

C_2H_6O

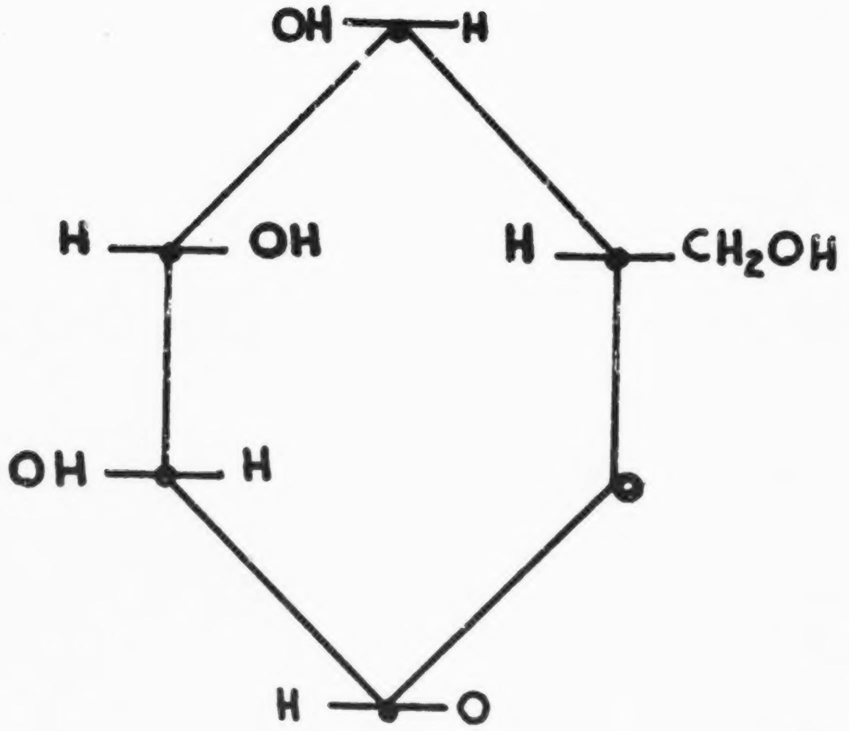
Six atoms of hydrogen

Two atoms of carbon

One atom of oxygen



$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-O-H$

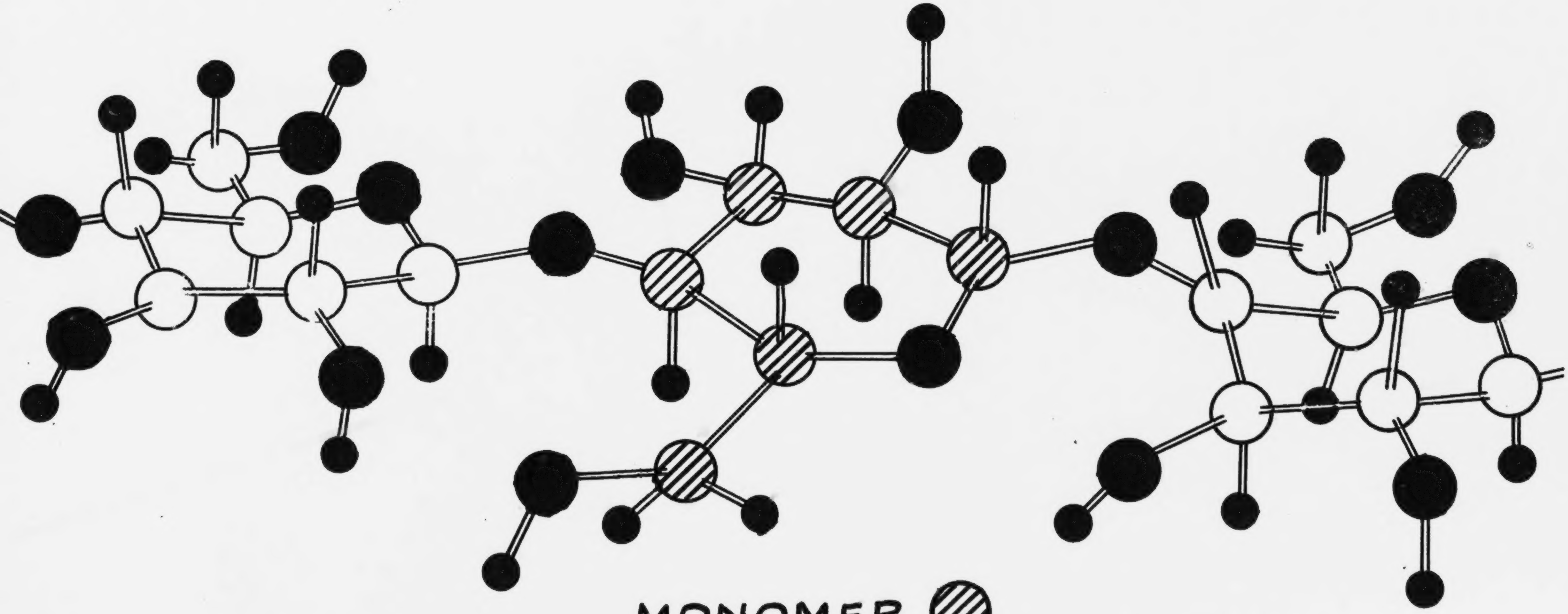

OH
H
H
OH
H
CH_2OH
OH
H
O
H
O

CELLULOSE MOLECULE

CARBON OXYGEN HYDROGEN
COMPOUND

NATURAL POLYMERS

CELLULOSE

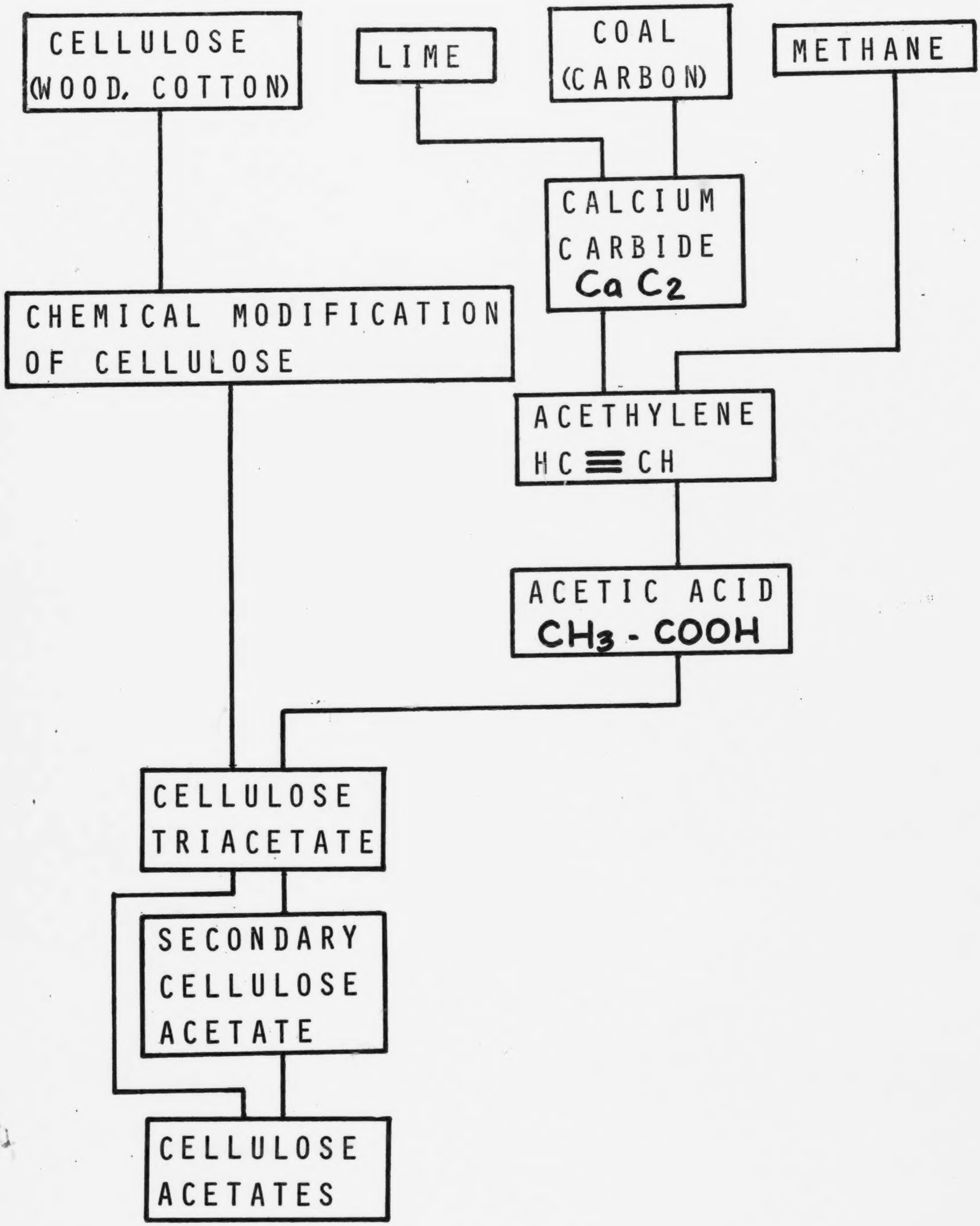


MONOMER ▨

CARBON ●   HYDR●GEN   OXYGEN ○

THE CHEMICAL STRUCTURE OF CELLULOSE ACETATES

IN LINE CHART FORM


CELLULOSE (WOOD, COTTON)
LIME
COAL (CARBON)
METHANE
CALCIUM CARBIDE CaC_2
CHEMICAL MODIFICATION OF CELLULOSE
ACETHYLENE $HC \equiv CH$
ACETIC ACID CH_3-COOH
CELLULOSE TRIACETATE
SECONDARY CELLULOSE ACETATE
CELLULOSE ACETATES

ACRYLICS Pattern of consumption

Market	1966 million lb.	1967 million lb.
Cast sheet	135	141
Coatings	49	51
Molding and extrusion powder	60	64
Miscellaneous	31	32
Total	**275**	**288**

CELLULOSICS Pattern of consumption

Market	1966 million lb.	1967 million lb.
Continuous sheet: under 3 mils	22.4	18
3 mils and over	49.6	46
All other sheet, rod, tube	8.0	6
Molding, extrusion materials	102.9	97
Total	**182.9**	**167**

Table 1—General Properties of Cellulose Acetate

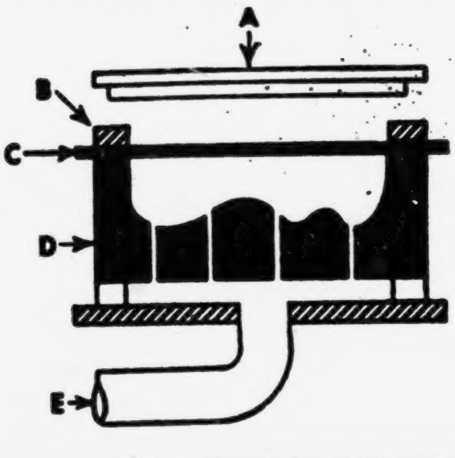
	ASTM Test	Value
Hardness, Rockwell	D785	R35 to R125
Permeability, films (cu cm-mil/sq m-24 hr-cm Hg diff)		
Water vapor	-	400 to 600
Oxygen	-	40 to 70
Carbon dioxide	-	250 to 350
Ethylene	-	15 to 100
Ethylene oxide	-	350 to 4000
Sulfur dioxide	-	350 to 1500
Specific Gravity	D792	1.23 to 1.34
Thermal Conductivity (cal-cm/sec-sq cm-deg C)	C177	4×10^{-4} to 8×10^{-4}
Heat Deflection Temperature (F)		
at 264 psi	D648	111 to 190
at 66 psi	D648	120 to 205
Coefficient of Thermal Expansion (per deg C)	D696	8×10^{-5} to 16×10^{-5}
Transparency—total light transmission (percent)	D1003-597	91 to 92
Index of Refraction	D542	1.46 to 1.50
Haze (percent)	-	2 to 3
Water Absorption (percent)	D570	1.9 to 4.5

Table 2—Mechanical Properties of Cellulose Acetate

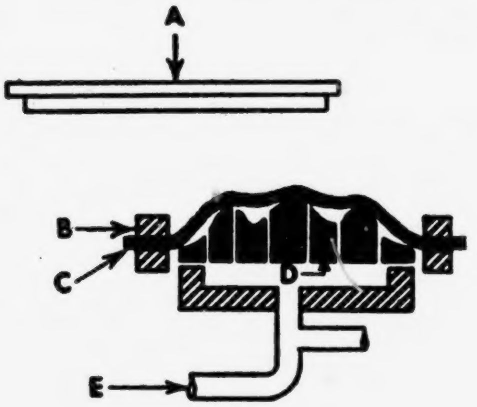
	ASTM Test	Value
Tensile Strength (psi)	D638	1900 to 8500
Compressive Strength (psi)	D695	2200 to 36,000
Flexural Strength (psi)	D790	2000 to 16,000
Impact Strength, Izod (ft-lb per in. notch)	D256	0.4 to 5.8
Flexural Modulus (10^5 psi)	D790	0.86 to 4
Elongation (percent)	D638	6 to 70

BASIC TECHNIQUES FOR THERMOFORMING SHEET

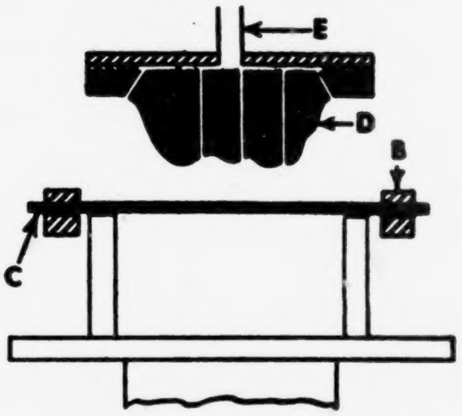
1. STRAIGHT VACUUM FORMING



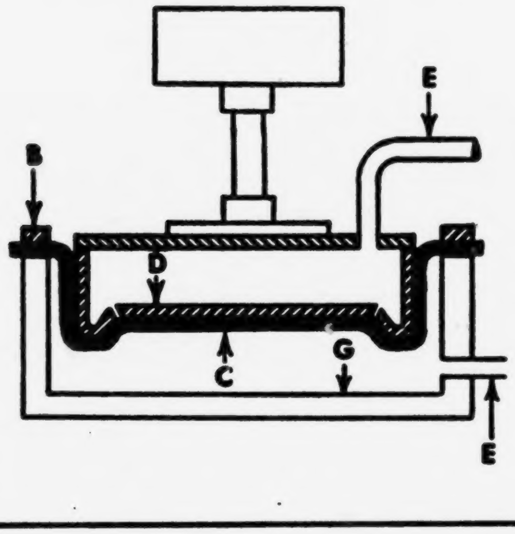
2. DRAPE VACUUM FORMING



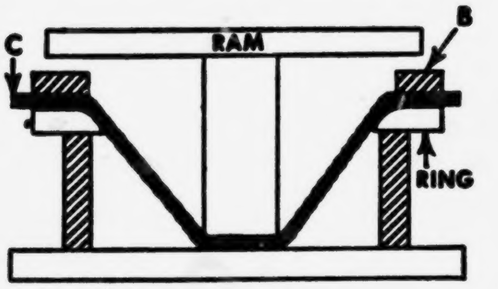
3. FORCE ABOVE SHEET



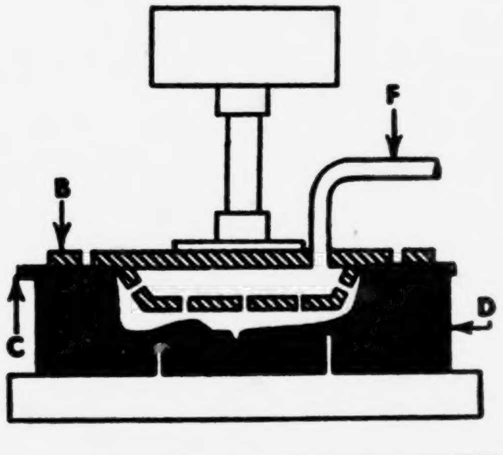
4. VACUUM SNAP-BACK FORMING



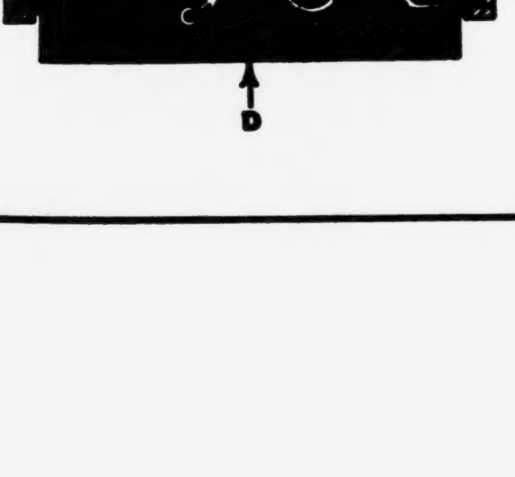
5. PLUG and RING FORMING



6. FORMING INTO FEMALE WITH HELPER AND AIR PRESSURE



7. PRESSURE FORMING



IN THESE SIMPLIFIED schematics of seven basic methods, letters indicate the following: A = Heater; B = Clamp; C = Plastic Sheet; D = Mold; E = Vacuum Line; and F = Air-Pressure Line. The methods (fully described in the text) are as follows: 1) Straight vacuum forming. Clamped in a statio[illegible] frame, the heated sheet is vacuum drawn into the mold. 2) Drape [illegible]um forming. Moveable frame or clamp drapes the sheet, softened by heat, over male mold before vacuum is pulled. 3) Force above sheet. Mold descends onto heated sheet, partially forming it; then the vacuum is pulled. 4) Vacuum snap-back forming. Vacuum is pulled, drawing pre-heated sheet into cavity G. Male plug moves down until it reaches a predetermined position. Vacuum is then applied through male plug. 5) Plug and ring forming. Heated sheet is placed over a ring and clamped down. Mold mounted on ram is forced into it. 6) Forming into female with helper and air pressure. As press closes, cored plug pushes heated sheet into cavity. Air pressure, introduced through plug, pushes sheet into female mold. Holes in mold let air escape. 7) Pressure forming. After heating, framed sheet is formed between matched male and female dies.

courtesy of Modern Plastics Encyclopedia

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: Joseph Braco
State University College
Oswego, New York

INSTRUCTIONAL LEVEL: College

TITLE: Identification, Classifications and Definition of Polymers

PRESENTATION TIME: 1 1/2 hours

INTRODUCTION:

Today polymers are accepted as basic materials used by designers and engineers. They play an important and vital role in our society. With so many polymers available today, an understanding and identification of these various materials are a must for the competent consumer.

The choice of a particular polymer now includes thousands of available types and formulations. It is easier to cope with this diversity if polymers are not considered a single family of materials--like the steels-- but rather as a category of materials--like the metals--embracing some 30 distinct families.

As in metals, new forms of polymers are created by alloying or by varying processing techniques. The alloying elements may be other polymers or non-plastic polymers. Or they may be other organic chemicals--dyes, inhibitors and plasticizers. Polymer resins may be converted into solid forms, foams, films or coatings.

New polymer materials may also be created by the addition of fillers or reinforcing materials to the base resin. Uniquely, the ranks of polymers have grown by synthesis of new molecules or atomic rearrangement of existing molecules. (trans. A-1)

OBJECTIVES:

Identification of various polymers
General understanding of polymers
To learn how the main polymers are classified

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Polymers

INTER-RELATION WITH OTHER SUBJECTS:
1. Metals
2. Chemistry

3. Textiles
4. Wood
5. Ceramics
6. Electricity, Electronics

USE IN INDUSTRY:

Experiences, such as World War II, have taught us the value of concerted effort--the concentration of teams of scientists, engineers, etc. to tackle our complex problems. Identification and classification of our highly developed materials, such as polymers, play a vital role in the systems of industry. Without such data, we would still have the big gap from discovery to final product as used to be the case years ago.

MATERIALS AND EDUCATIONAL MEDIA:

Transparencies noted as noted (trans. B-2)
Samples of the various polymers
Films - Kingdom of Plastics, General Electric Company
    Origin and Synthesis of Plastic Materials, Visual Education Office, U.S. Office of Education
    Physical Chemistry of Polymers
Student Activity:
1. Build molecular structures
2. Identify various polymers visually
3. Make mechanical and chemical identification tests

PRESENTATION:

Definition 1. Polymers is the name of a large and varied group of materials which consist of or contain as an essential ingredient a substance of high molecular weight which, while solid in the finished state, at some stage of its manufacture is soft enough to be formed into various shapes--usually through the application of heat and pressure.

2. Polymers are a class of synthetic organic materials (resins) which are solid in the finished form, but at some stage in their processing, are fluid enough to be shaped by heat and pressure.

3. Polymers in finished form consist of long chain molecules called "polymers." Smaller building block molecules often may be combined into polymers by catalysis, heat and pressure. Cross-linking of two or more polymers, a process analogous to alloying in metals, is known as copolymerization. (trans. A-3)

4. Polymers come in many forms, such as liquids, films, powders, pellets, bars and sheeting. (show examples of the above materials)

CLASSIFICATION:

Polymers can be divided into two major groups or families--thermoplastics and thermosets.

Thermoplastics are those groups of polymers that become soft when exposed to heat and hardened when heat is removed. They may be softened and resoftened repeatedly without undergoing a change in chemical composition.

Thermoset polymers are those groups of polymers that set into permanent shape when heat and pressure are applied during forming. These resins undergo a chemical change with the application of heat and pressure and cannot be resoftened. (Show samples of the two above)

The Society of the Plastics Industry (S.P.I.) has classified nearly all of the industrial polymers into a letter and number system somewhat similar to the SAE system that the steel industry uses. It is intended to promote and encourage the intelligent use of polymers. The classification characterizes the various molding materials, primarily in terms of three physical properties usually believed to be of controlling significance, such as heat distortion temperature, impact strength and tensile strength.

An example of this is CP10502 (trans. A-4)

CP - means cellulose propionate
10 - the first 2 digits mean its heat-distortion temperature at 264 psi stress which in this case is 100° F.; the last digit is dropped.
50 - the third and fourth digits represent its impact strength.
2 - the fifth digit, 2, represents its tensile strength in thousands of psi (2000)

IDENTIFICATION:

Some of the common polymers are as follows: (trans. A-5)

ABS
Acrylics
Cellulosics Acetate
Acetate, Butyrate, Nitrate
Epoxy
Fluorocarbons
Melamine
Phenolics
Polyester
Polyethylene
Polypropylene
Polystyrene
Polyurethane
Silicone
Urea
Vinyl

DEFINITION OF TERMS:

Acrylic Plastics - polymers based on resins made by polymerization of acrylic monomers
Alkyd Plastics - polymers based on resins of saturated polymeric esters.
Catalyst - a substance which when added in minor proportions accelerates a chemical reaction.
Cohesion - The forces holding a single substance together.
Cross-linking - The development of chemical linkages between long chain molecules.
Degradation - a deleterious change in the chemical structure of a plastic.
Elastomer - a material which at room temperature can be stretched repeatedly to at least twice its length and return to original length upon release of stress.
Epoxy Plastics - polymers based on resins made by the reaction of epoxides with other materials such as alcohols, phenols and acids.
Ethylene Plastics - polymers based on resins made by the polymerization of ethylene or copolymerization of ethylene with other unsaturated compounds.
Inhibitor - a substance which prevents or retards a chemical reaction.
Monomer - a relatively simple chemical which can act to form a polymer.
Phenolic Plastics - polymers based on resins made by the condensation of phenols.
Plasticize - to soften by addition of plasticizer.
Polyester Plastics - polymers based on resins of polymeric esters.
Polymer - a compound formed by the reaction of simple molecules.
Polymerization - a chemical reaction in which the molecules of a monomer are linked together.
Resin - an organic material which has an indefinite and often high molecular weight.
Thermoelasticity - rubber-like elasticity exhibited by a rigid plastic and resulting from an increase of temperature.
Thermoforming - forming with the aid of heat.
Urea Plastics - polymers based on resins made by the condensation of urea and aldehydes.
Viscosity - the property of resistance to flow exhibited within the body of a material.
Yield Value - the force which must be applied to a plastic to initiate flow, also called yield stress.

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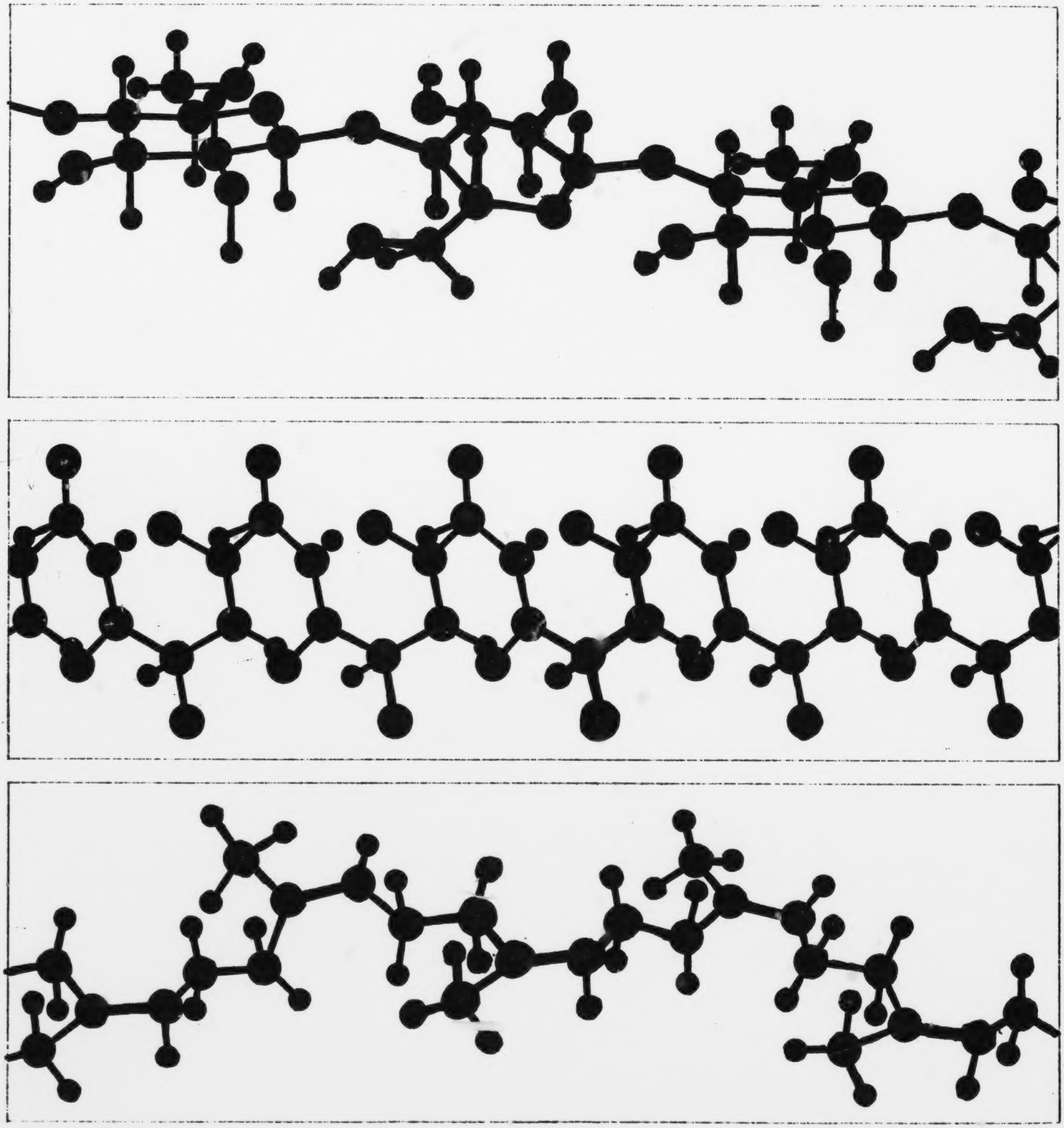
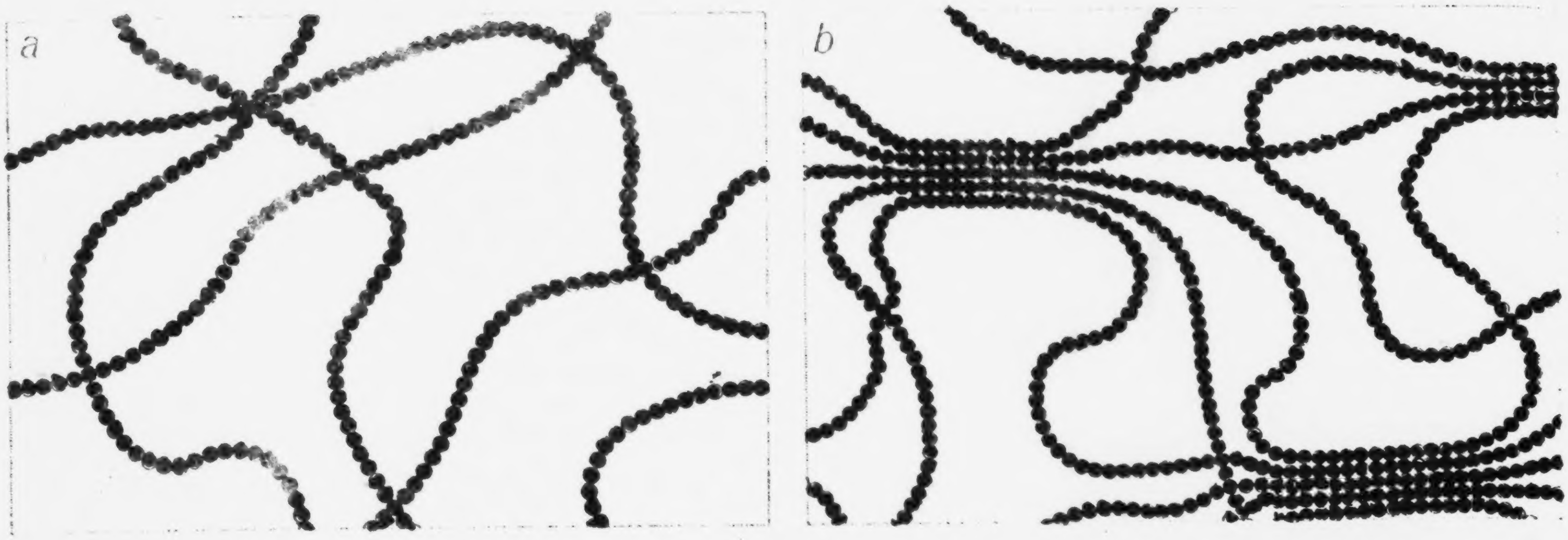
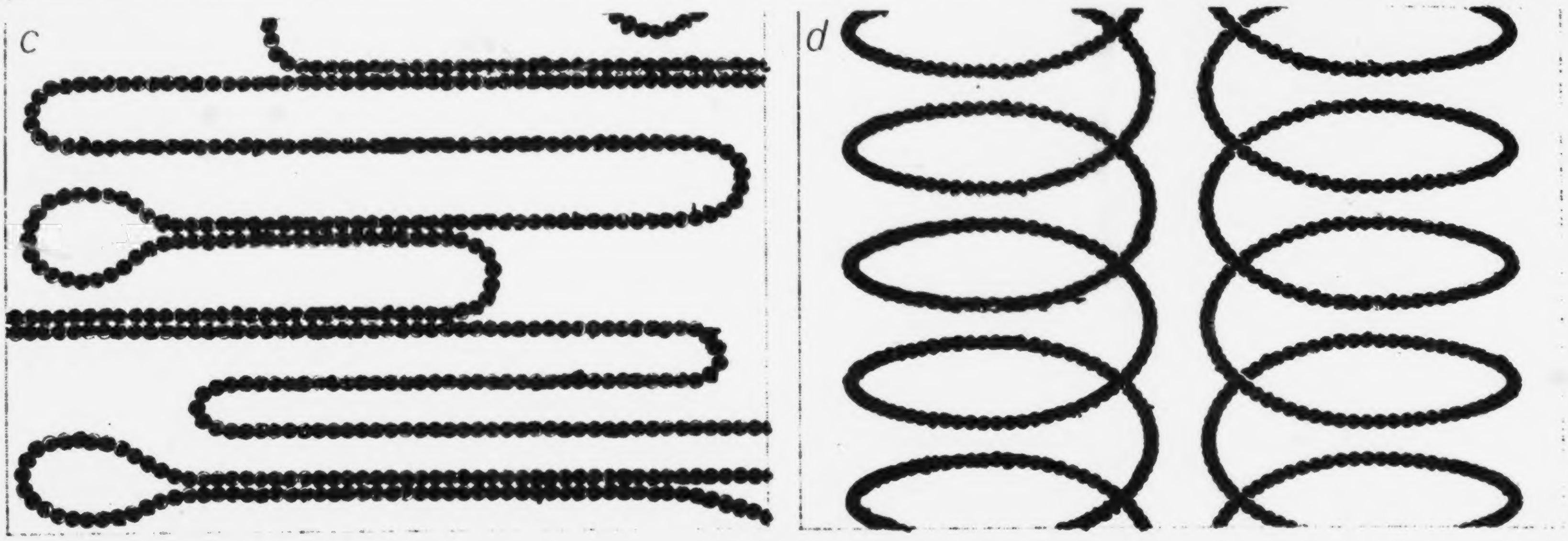


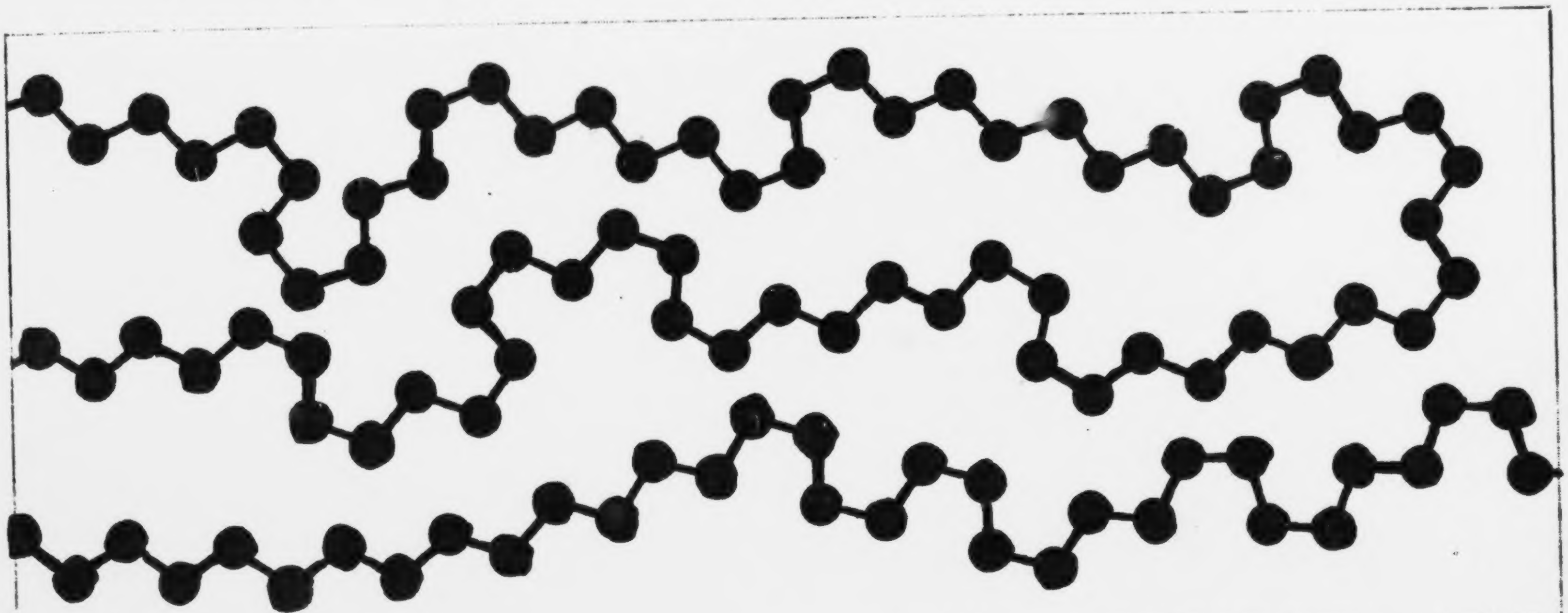
NATURAL POLYMERS include cellulose (*top*), animal protein (*center*) and rubber (*bottom*). Monomers are in color. Atoms are carbon (*dark*), nitrogen (*light*), oxygen (*large open circles*) and hydrogen (*small open circles*). Each *R* represents a side chain.



SYSTEMS OF POLYMER CHAINS include amorphous arrays (*a*) and various forms of crystallization. There can be crystallization between chains (*b*) and also chain-folding, which is crystallization of a chain on itself. Chain-folding can take a laminar form

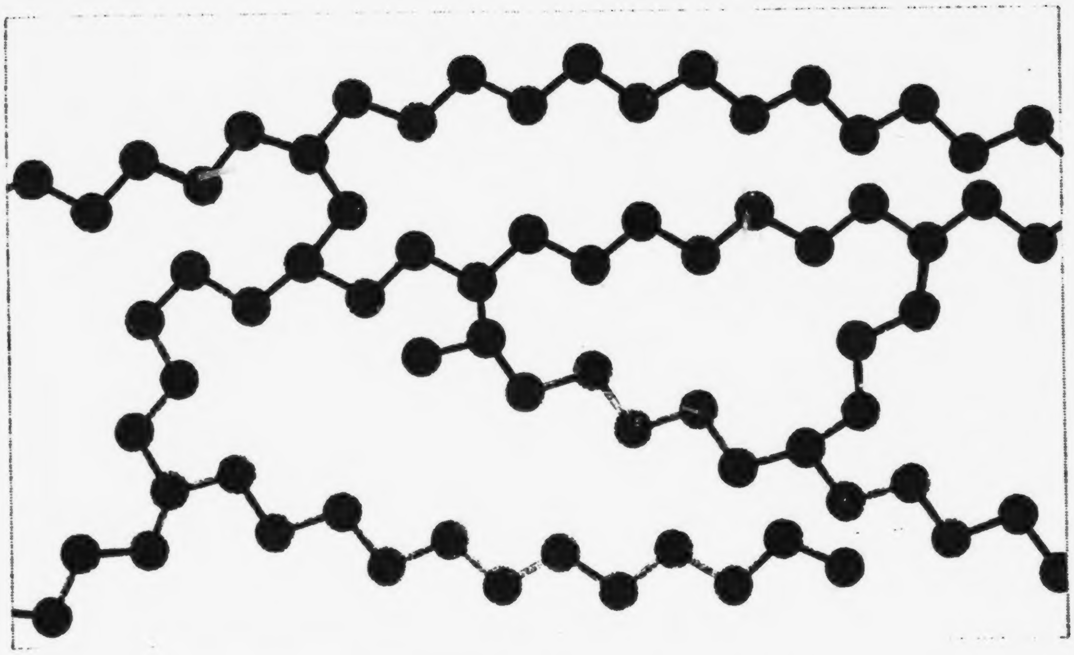


(*c*) or a helical form (*d*); the helical form can be either left-handed or right-handed. A predominantly amorphous polymer is soft, elastic and permeable to fluids; a polymer with a predominantly crystalline structure is appreciably stronger and more rigid.

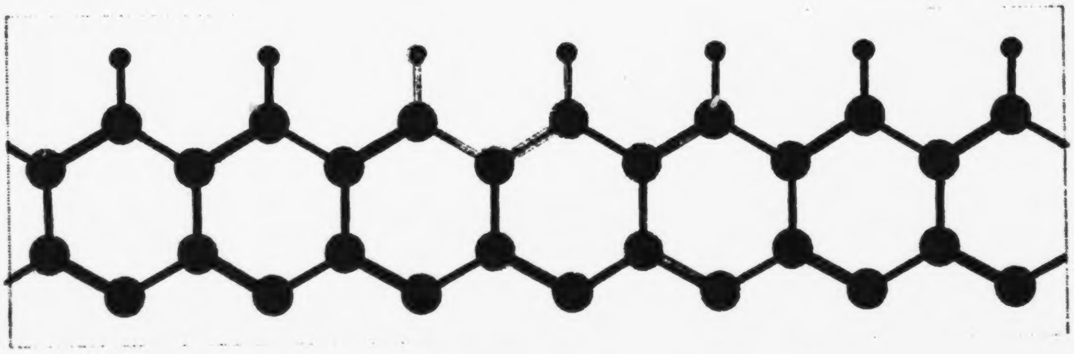


FLEXIBLE CHAIN of a polymer is represented by polyethylene above melting temperature. For clarity only carbon atoms are shown. Such a chain is flexible because its segments are linked by rotatable bonds. A polymer of such chains can be strengthened by orientation and crystallization, which are shown in the top illustration on these two pages, or by cross-linking

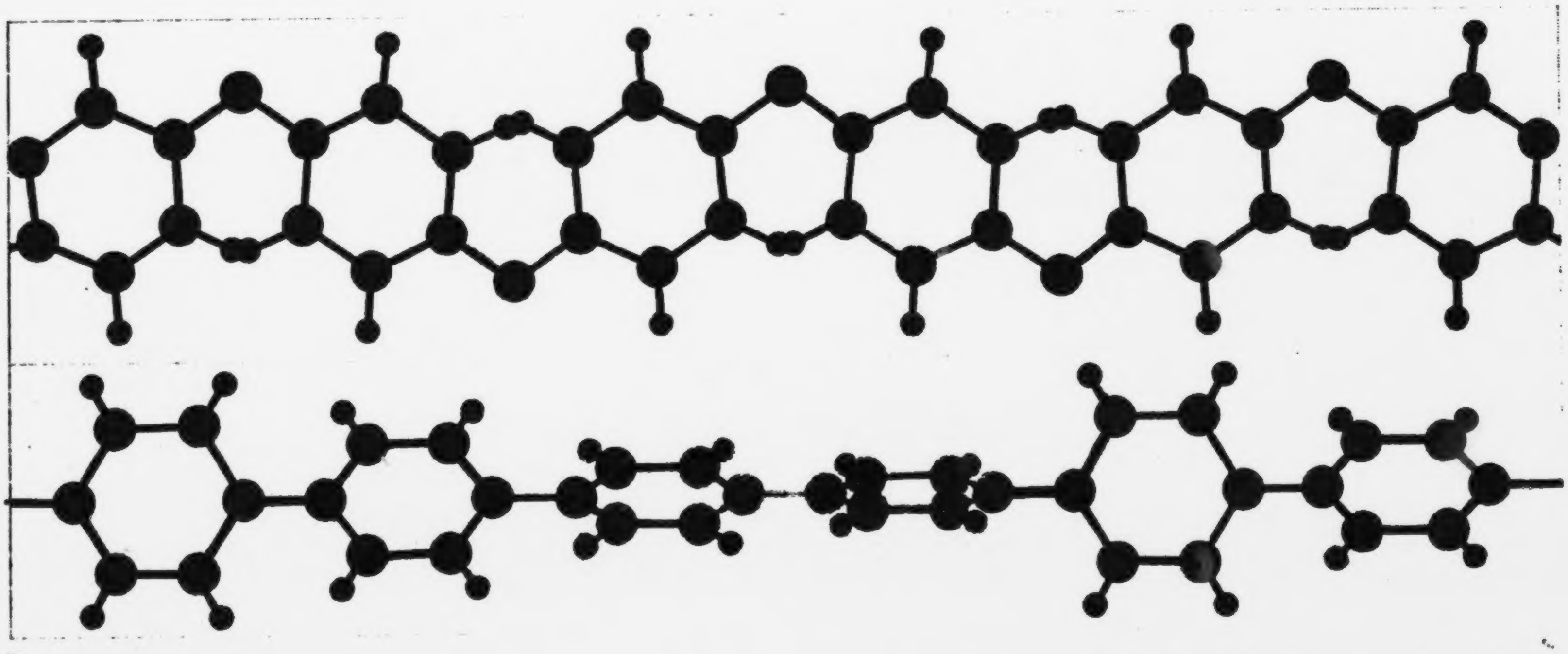
A-3



CROSSLINKING of p[illegible] chains [illegible] a substance to a polymer in order to induce the [illegible] The crosslinks usually form at random places between [illegible] hydrogen atoms of the chain have been omitted for clarity.



"LADDER" POLYMER achieves rigidity by a technique of bonding ring structures at two adjacent carbon atoms. The effect resembles that of hanging a door by two hinges. As a result of the arrangement adjacent rings of the polymer chain have a restricted mobility.



INFLEXIBLE CHAINS provide rigidity in a polymeric material. At top is a chain of polystyrene that has been made relatively inflexible by the addition of benzene rings to the carbon backbone of the chain; because of them the molecules cannot bend sharply and so remain relatively straight. At bottom is an intrinsically stiff chain of polyphenylene: it can twist on its bonds but cannot bend.

CP 10502

S.P.I. CLASSIFICATION SYSTEM

POLYMERS

THE THERMOSET FAMILY

AMINO	DISHES COUNTERTOP MATERIALS ADHESIVES SWITCHES SIZINGS
CASEIN	KNITTING NEEDLES BUTTONS DRESS BUCKLES NOVELTIES
EPOXY	ADHESIVES SURFACE COATINGS ELECTRICAL COMPONENTS
PHENOLIC	APPLIANCE HANDLES T-V CABINETS DISTRIBUTOR CAPS ADHESIVES
POLYESTER	BOAT & AUTO STRUCTURES COATINGS SPORTS EQUIPT. BUILDING MATERIALS
SILICONE	MOLD RELEASES TAPE ADHESIVES ELECTRICAL COMPONENTS
URETHANE	FOAMS INSULATION COATINGS RUG PADS AIRCRAFT PARTS

POLYMERS

THE THERMOPLASTIC FAMILY

ACRYLIC	SIGNS AUTO TAIL LIGHTS CONTACT LENSES CONTROL PANELS
CELLULOSIC	PACKAGING TOOTH BRUSHES STEERING WHEELS EYEGLASS FRAMES
POLYAMIDE (NYLON)	GEARS FABRICS SHOWER HEAD VALVES PIPING
POLYOLEFIN POLYETHYLENE POLYPROPYLENE	SQUEEZE BOTTLES PACKAGING INSULATING COVERS CONTAINERS
POLYSTYRENE	FOOD CONTAINERS BATTERY CASES CABINETS INSULATION PIPING
VINYL	FLOOR COVERING RAIN WEAR SCREENING CEILING FIXTURES

LOCATION	POLYMER CHARACTERISTICS	EXAMPLES	USES
1	Flexible and crystallizable chains	POLYETHYLENE	Pails, pipes, thin films
		POLYPROPYLENE	Steering wheels
		POLYVINYL CHLORIDE	Plastic pipes and sidings
		NYLON	Stockings, shirts, dresses, coats
2	Cross-linked, amorphous networks of flexible chains	PHENOL-FORMALDEHYDE	Television casings, Telephone receivers
		CURED RUBBER	Tires, transport belts, hoses
		STYRENATED POLYESTER	Finish on automobiles and appliances
3	Rigid chains	POLYMIDES	High-temperature insulation
		LADDER MOLECULES	Heat shields
A	Crystalline domains in a viscous network	TERYLENE (DACRON)	Fibers and films
		CELLULOSE ACETATE	Fibers and films
B	Moderate cross-linking with some crystallinity	NEOPRENE	Oil-resistant rubber goods
		POLYISOPRENE	Particularly resilient rubber goods
C	Rigid chains, partly cross-linked	HEAT-RESISTANT MATERIALS	Jet and rocket engines and plasma technology
D	Crystalline domains with rigid chains between them and cross linking between chains	MATERIALS OF HIGH STRENGTH AND TEMPERATURE RESISTANCE	Buildings and vehicles

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: Wayne A. Douglas
Central High School
Akron, Ohio

INSTRUCTIONAL LEVEL: College or high school

TITLE: Polymers - Polyester

PRESENTATION TIME: Jr. High - 1 hr, Sr. High - 4 hrs., College 8 hrs.

INTRODUCTION:

The term"polyester"encompasses several plastics. To be more specific, polyesters may be classified as either saturated or unsaturated. Both groups are however memebers of a family formed through addition polymerization of dibasic acids with polyfunctional alcohols. Most polyester resins are thought to be thermosetting, but some have the structure of a thermoplastic material. Mylar film, and Dacron are two examples of saturated polyester resins. Another polyester resin called alkyd is commonly used to refer to those materials that have been modified with vegetable oils or fatty acids. These materials are widely used in paints and other coatings. The most common polyester resin is used in fibrous glass reinforced plastics. This material is an unsaturated thermosetting polyester, 100% polymerizable resin.

OBJECTIVES:

1. To review the various types of polyesters, placing major emphasis on the unsaturated thermosetting polyester.
2. To acquaint the student with the various materials used in reinformed plastics, particularly polyesters.
3. To review the outstanding properties and characteristics of polyester reinforced resins.
4. To acquaint the student with a few of the more common reinforcing agents.
5. To provide the student with the opportunity to develop his own tests and investigation concerning the relative strengths of reinforced plastics.
6. To acquaint the student with technical data pertaining to the unique properties of reinforced plastics.
7. To demonstrate the tensile and impact strength of uni-directional and random reinforced plastic test strips through a series of comparative tests.

8. To encourage the student to perhaps seek a better way and to always ask why when experimenting with a particular material.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Polymers (Plastics)

INTER-RELATION WITH OTHER SUBJECTS
Organic Chemistry, Physics, Economics.

USE IN INDUSTRY:

Despite the present preponderance of unsaturated polyesters going into reinforced application, there are important indications of significant growth in the area of non-reinforced uses. One such example is the casting of imitation pearl buttons based on polyester.

The construction industry utilizes the pure resin in the application of a gel coat to the mold surfaces prior to applying reinforcement and resin. Similar polyester formulations either colored or pigmented, are finding increased usage as a glazed finish for concrete block and other masonry surfaces.

Special polyesters and techniques are being developed and evaluated as both mortar and sealcoat type overlays for terrazo flooring, table tops, concrete bridge decks and highway pavements.

The electrical industry is using a fair amount of polyesters for casting and impregnation.

One of the largest outlets for reinforced polyesters is in the transportation industry. The Corvette auto body continues to be one of the largest single items. Polyester FPR is receiving increased usage in modern public rail and bus systems, however its main use lies in construction in the form of corrugated or flat translucent panels for patio covers, skylights, and glazing.

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT:

SAFETY:
Keep material or resin off of skin and away from eyes.
Work in well ventilated room
Keep away from open flame.

INTRODUCTION: POLYMERS - POLYESTER

1. Classification of Family:
   Thermoset: a plastic material that undergoes a chemical polymerization reaction, or cure, when heated or alcalyzed. Reheating does not reverse the process.
2. Structure and Composition
   A. Generally: Polyester is formed by polymerization of diabasic acids with polyfunctional alcohols.
   B. Saturated, Unsaturated, & Alkyd Polyesters
      1. Saturated: Dacron, Mylar
      This material is identified by, on the molecular level, having each carbon atom within its chain surrounded by a full compliment of neighboring atoms. Since there is no way for additional atoms to be added to the chain, these molecules are considered to be saturated. Molecules of this type possess strong intra-molecular covalent bonds and weaker intermolecular van der Waals bonda. They can be identified by their relatively low melting points. The degree of cross linking is also very low.
      2. Unsaturated: Resin in FPR
      This type of molecule is identified by double bonded linear molecules that are not saturated with the maximum number of hydrogens. In seeking to become stable, considerable cross-linking and branching is likely to occur. This material can be identified by its high melting points.
      3. Alkyds: Enamels, Varnishes
      This material is identified as an unsaturated polyester usually compounded with low volatility monomer and fillers into a doughy or sometimes dry product which is used in hot compression molding.
   C. Degree of Functionality:
   Basically the functionality of polymerization molecules is expressed as the number or reaction points in a molecule that can function in tying it to some other molecule.
   If the functionalities of either of two or more reacting molecules is only 1, no polymer will be formed. If the functionality of both constituents is 2, a thermoplastic will result; if one reacting molecule has a functionality of 3 or more and the other has a functionality of 2 or more, a cross-linked thermoset polymer can result.

D. Inhibitors:

During the precatalyzed stage, the base resin monomer combination is only a simple liquid mixture. However, some type of chemical inhibitor is necessary to prevent premature polymerication in the cooking kettles. Also some inhibitors are necessary to maintain stability of the material in storage.

The actual mechanism of inhibition is not completely clear. It is suspected that the inhibitors react with active polymer growth centers, preventing polymerization. The inhibitors can be removed or at least their effectiveness can be terminated by heat, by promoters (catalysts) or by other conditions which actually induce polymerization. The inhibitor in some cases is actually allowed to remain in the monomer but should not be of the type to seriously interfere with polyester polymerization.

E. Catalysts, Curing Agents, or Promoters

These are agents which generally trigger addition polymerization. Although polyesterification, the combining of an acid and an alcohol to produce the by product H_2O takes place as a "condensation" polymerization reaction, the ultimate thermoset cure of a polyester essentially takes place due to "addition" polymerization. There are generally four ways to trigger addition polymerization: thermal or photochemical means, which require no chemical catalyst; free radical or ionic means which involve catalysts.

Free radicals are essentially responsible for polyester polymerization, and these are most generally supplied from decomposition by heating of, or action of a promoter or an organic peroxide.

The free radicals react with the chemical inhibitor dissipating it. They also serve to open the soluble bonds in the polyester linear chain to set in motion that portion of the polymerization process designated as initiation.

3. Reinforcing Materials

Reinforcements are those materials used to increase the strength of plastics several-fold. Reinforcements differ from fillers in that fillers are intended primarily to reduce costs, although fillers often give a slight improvement in strength.

Many types and forms or reinforcements are used. Glass fibers are of course predominant, although asbestos is achieving substantial usage, especially in high temperature applications.

Many types and forms of reinforcement are used. Glass fibers are of course predominant, although asbestos is achieving substantial usage, especially in high temperature applications.

Fibrous glass reinforcements are used as woven fabrics of many types, nonwoven mattings, bulk-chopped and milled fibers and unidirectional rovings, yarns, and beams.

The Fabrics range from 0.002 - 0.200 in in thickness and can be tight or open woven. Most are "balanced", that is they have almost equal amounts of glass in each direction, but some are "unidirectional" having most of the fibers in one direction.

4. Parting Agents

It is of course important that from the beginning of the lay-up of a molding that the surface be treated by application of a substance which will prevent the plastic from adhering to the mold. Not only is the choice of parting agent important, but also care must be taken in selecting the method of application.

Considerations governing the decision are:

a. Type of mold material and its surface finish
b. Type of resin, pigment, filler, solvent, and reinforcing agent
c. Surface hardness and finish required on the molded article
d. Temperature and pressure during molding cycle
e. Ease of application of parting agent and frequency of required application

On porous molds, the parting agent should be a film or of film forming type. On nonporous molds, the parting agent may be a lubricant.

The type of resin impregnant is a factor in the choice of parting agent, since interaction between resin and agent cannot be tolerated.

5. Solvents

Mix tanks and resin containers are usually cleaned with solvents. However, because of the potential vapor inhalation and dermititis problem, the use of alkaline cleansers and detergents are now recommended.

A common practice on the part of employees has been to remove dried resins and other materials from the hands by frequent washing in acetone. This has led to subsequent dermatitis, sometimes followed by infection, because of the ability of acetone to defat and dry the skin. The use of solvents in large quantities to clean molds should be avoided in order to limit solvent contact with the skin, inhalation of the vapor or eye irritation that may result from this practice. Utilizing the smallest quantities to do the job and hand applications where possible is much more desirable than using a solvent-soaked rag in contact with the hand.

Common solvents used in industry are: acetone, toluene, methyl ethyl ketone, methyl cellulose, ethylene glycol, diethylene glycol,

6. Properties

In general, the important characteristics of polyester resins include good electrical and physical properties, easy handling, solidifying without evolution of gaseous or liquid by-products, and good dimensional stability, By addition of small amounts of other materials, polyesters may also be made flame resistant, heat resistant, corrosion resistant, and stable against the effects of high heat and weather.

Although most thermosetting plastics are reinforced with fillers, whether in powder or fiber form, the term "reinforced plastics" is used almost exclusively to describe glass-fiber reinforced plastics. Some of the reasons which make polyester resins and glass fiber such an excellent combination for reinforced plastics are: a. polyester resins are liquid and will therefore flow and impregnate glass fiber with little or no pressure, b. glass fiber is one of the strongest known materials and because it is glass, will not deteriorate with time, c. glass fiber is easily crushed - and polyester resin can be cured with little or no pressure, d. fully cured moldings and laminates have excellent physical properties and better strength-weight ratios than many metals. Good electrical properties and resistance to corrosion as well.

7. Industrial Production Methods or Processes:
    a. premixing
    B. contact molding - trans. 13
    C. Vacuum-bag molding - trans. 14
    D. matched die molding - trans. 15
    E. pressure-bag molding - trans. 16
    F. flexible-plunger molding - trans. 17
    G. molding compounds - trans. 18

PRESENTATION:

A. Overview of plastics - thermoplastic & thermoset trans. 1, 2; samples

B. Structure of Plastics - molecular chain, polymerization, catalyst-promoter, cross-link; trans. 3, 6, 7, 8, 9, 10, molecular models

C. Polyester Resin - thermoset family, list industrial applications, forms: liquid, granual, beads, pellets, types: saturated & unsaturated; trans. 11, 19, 7, molecular models, samples.

D. Properties - complete list; trans. 4 & 5, charts

E. Reinforcing Materials: rope, paper, wood,wire, glass,rock

F. Specific Reinforcing Materials: mat, cloth, rovings, chopped; samples

G. Solvents - types: acetone, lacquer thinner, release agents: PVC, paste wax

H. Safety - keep away from skin, proper clothing, keep away from open flame

I. Methods of Industrial Application - list; trans. 12, 13, 14, 15, 16, 17, 18, Demo. hand lay-up, matched-die, drape of contact, casting; property test - flexural: use 4 samples (1/8" x 1" x 7") 1-clear, 1-mat,1-cloth, and 1-chopped fibers of fiberglass. Attach spring scale to samples to measure stress, this will give a student a comparative figure to apply to samples.

STUDENT WORK EXPERIENCES AND EXPERIMENTS:

A. Prepare strips of equal size and the same amount of reinforcing material by weight. Subject these test strips to simple test whereby weights are placed on one end. This is a comparative test and accurate data can not be gathered, but will give the student some insight as to which samples will in effect hold the most weight - due to reinforcing material.
Encourage student to experiment with a variety of materials - and vary pressure vs. non-pressure to give some idea as to the differance between high and low pressure laminates.

B. Encourage student to collect commercially fabricated pieces of reinforced fiberglass and run comparative tests.

C. A simple chemical or solvent test to show the effects of these materials on polyester resin

D. The effects of temperature - fire is also an interesting experiment. By adding different fillers and reinforcing agents the student can also gain some insight as to how the engineer can change the physical properties of his material.

E. Let the students compile a list of where reinforced fiberglass is used in the home and industry. Examples of other uses of polyester resin, other than in reinforced fiberglass, should also be gathered. The students may be surprised to find that polyester is a rather versatile material.

F. Take the above list and try and determine which of the industrial processes would most likely be used in its production.

G. Try and develop a mass-production project using this material and one of the industrial production processes.

H. Experiment with different release agents and which should be used with certain molds.

I. Encourage students to experiment with their own molds. Let them design and develop them from scratch.

J. Encourage the students to build their own molding devices, such as flexible-bag, pressure-bag, and contact molding. They will in turn understand more of the limitations of the material in which they are working.

DEFINITION OF TERMS:

A. Catalyst - substance which markedly speeds up the cure of a compound when added in minor quantity as compared to the amounts of primary reactants.

B. Cross-linking - applied to polymer molecules, the setting-up of chemical links between the molecular chains. When extensive, as in most thermosetting resins, cross-linking makes one infusible super-molecule of all the chains.

C. Hardener - a substance or mixture of substances added to plastic composition, or an adhesive to promote or control the curing reaction by taking part in it. Term also used for substance added to control degree of hardness of cured film.

D. Polymerization - chemical reaction in which the molecules of a monomer are linked together to form large molecule

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TEACHER:

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4. "Materials" *Scientific American*
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LIQUID MEASUREMENT:
110 drops - 1 tsp
3 teaspoon - 1 tbsp
2 tablespoons - 1 ounce
4 " - 1/4 cup
16 " - 8 oz or 1 cup
2 cups - 1 pint
2 pints - 1 quart
4 quarts - 1 gallon

RESIN PER SQUARE FOOT (APPROX AMTS)
gel coat .010 to .020 - 1/2 - 1 oz
finishing mat .010 to .030 - 1 - 2 oz
2 oz gloss cloth .003 - 1 oz
10 oz gloss cloth .013 - 3 - 4 oz
10 oz woven roving .016 - 3 oz
35 oz woven roving .034 - 8 - 10 oz
3/4 oz chopped strand mat - 2 - 4 oz
1 - 1/2 oz chopped strand mat - 4 - 6 oz
3 oz chopped strand mat - 8 - 10 oz

POLYMERS

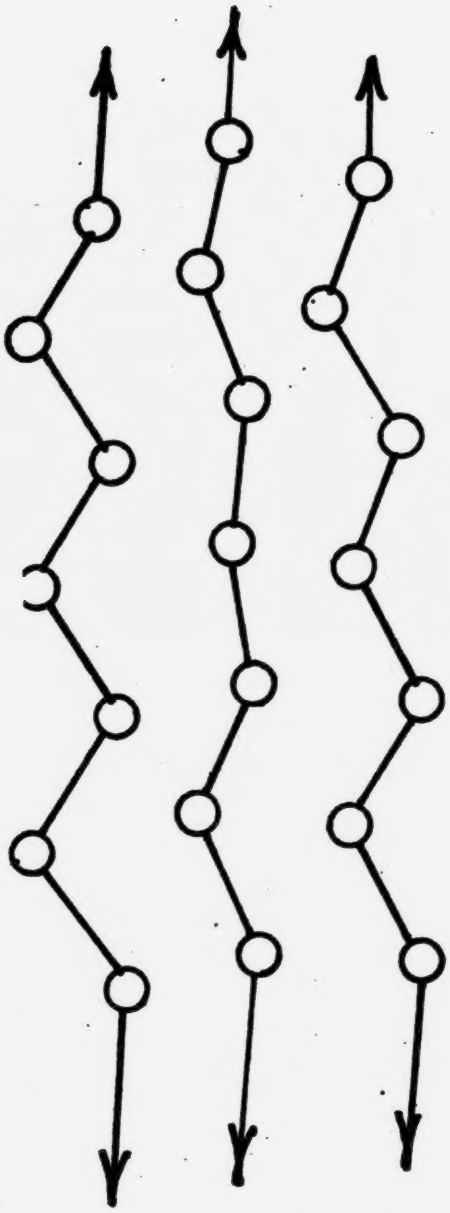
THE THERMOPLASTIC FAMILY

ACRYLIC	SIGNS AUTO TAIL LIGHTS CONTACT LENSES CONTROL PANELS
CELLULOSIC	PACKAGING TOOTH BRUSHES STEERING WHEELS EYEGLASS FRAMES
POLYAMIDE (NYLON)	GEARS FABRICS SHOWER HEAD VALVES PIPING
POLYOLEFIN POLYETHYLENE POLYPROPYLENE	SQUEEZE BOTTLES PACKAGING INSULATING COVERS CONTAINERS
POLYSTYRENE	FOOD CONTAINERS BATTERY CASES CABINETS INSULATION PIPING
VINYL	FLOOR COVERING RAIN WEAR SCREENING CEILING FIXTURES

POLYMERS

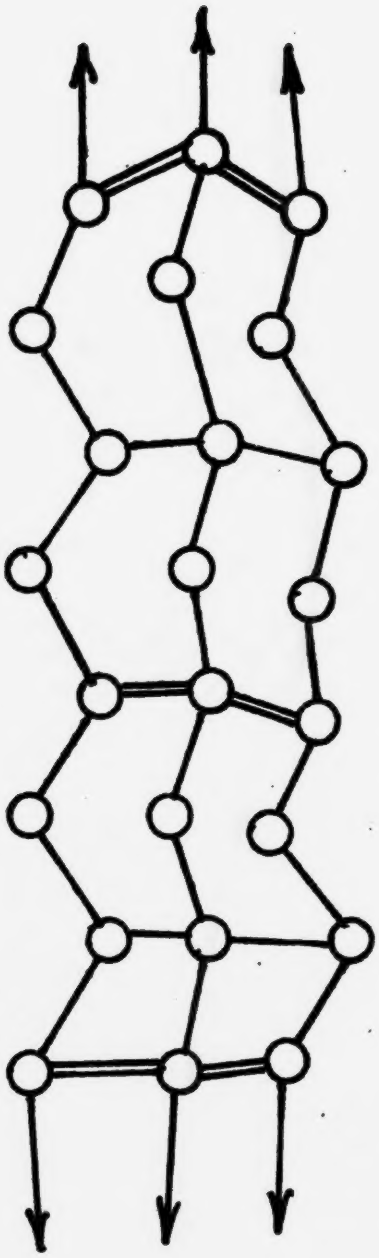
THE THERMOSET FAMILY

AMINO	DISHES COUNTERTOP MATERIALS ADHESIVES SWITCHES SIZINGS
CASEIN	KNITTING NEEDLES BUTTONS DRESS BUCKLES NOVELTIES
EPOXY	ADHESIVES SURFACE COATINGS ELECTRICAL COMPONENTS
PHENOLIC	APPLIANCE HANDLES T-V CABINETS DISTRIBUTOR CAPS ADHESIVES
POLYESTER	BOAT & AUTO STRUCTURES COATINGS SPORTS EQUIPT. BUILDING MATERIALS
SILICONE	MOLD RELEASES TAPE ADHESIVES ELECTRICAL COMPONENTS
URETHANE	FOAMS INSULATION COATINGS RUG PADS AIRCRAFT PARTS



THERMOPLASTIC

Chain-like



THERMOSET

Cross-links

PROPERTIES OF THERMOSETS

	AMINOS	CASEIN	EPOXIES	PHENOLICS	POLYESTERS	SILICONES	URETHANES
Specific Gravity	1.47-1.55	1.35	1.11-1.8	1.25-1.55	1.3	1.6-2.0	1.15-1.20
Tensile Strength (1000's psi)	5.0-13.0	10.0	4.0-9.0	4.0-9.0	4.5-25.0	4.0-35.0	Varies with rigid and flexible
Compressive Strength (1000's psi)	25-45	27-53	13-28	15-50	12-34	9-15	
Impact Strength	Good	Fair	Ex.ifRei.	Good	Ex.ifRef.	Good	
Clarity	Tri-0	T-0	T-0	Tri-0	T-0	0	0
Electrical Resistance	Good (low freq)	Fair	Excell.	Good	Good (lo Frq)	Excell.	Good
Heat Distortion Point (Degrees F.)	266-400	300	250-290	150-260	140-425	500-900	does not apply
Maximum Service Temp. (Degrees F.)	210-400	275	200-300	160-300	250-350	450	400
Burning Rate	None(SE)	S	S to SE	Sto none	S to SE	Sto none	S to SE
Water Absorption Rate	Low	High	Very low	Low	Low	Very low	Very low
Effect of:							
Weak Acids	Little	Little	None	Little	Little	Little	Little
Strong Acids	Decomp.	Decomp.	Att.Few	Attacked	Attacked	Little	Little
Weak Alkalies	Little	Decomp.	None	None	Attbysome	Little	Little
Strong Alkalies	Att.some	Decomp.	Little	Decomp.	Attacked	Little	Little
Solvents	None	Little	Little	Little	Attbysome	Attbysome	Little
Outdoor Conditions (Sunlight)	Discolor	Discolor	None	Discolor	Discolor	Little	Discolor on some

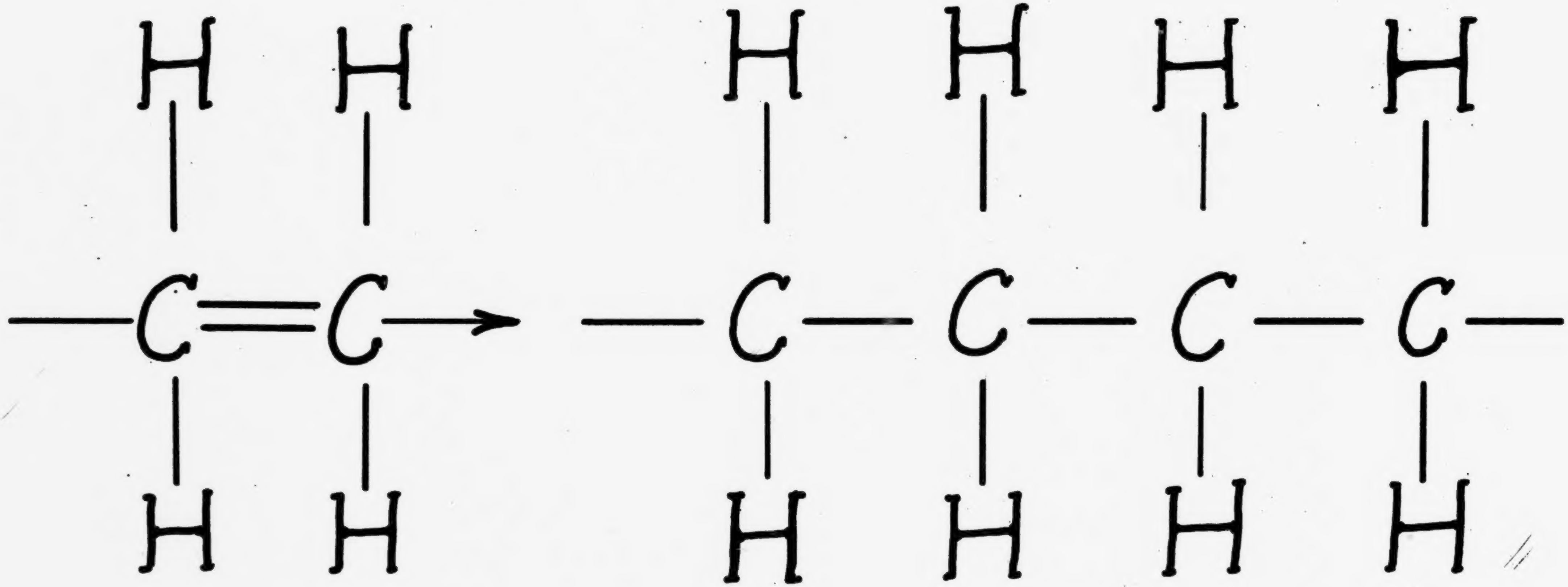
T - transparent, Tri - Translucent, O - Opaque S-slow, SE - self-extinguishing

PROPERTIES OF THERMOPLASTICS

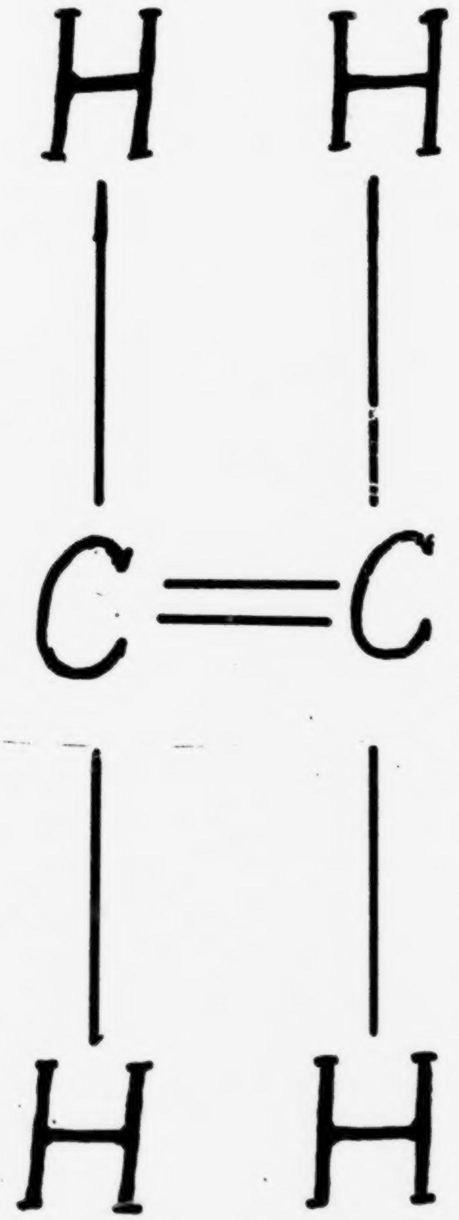
	ACETALS	ACRYLICS	CELLU-LOSICS	FLUORO-CARBONS	POLY-AMIDES	POLY-OLEFINS	STYRENES	VINYLS
Specific Gravity	1.4	1.17-1.20	1.15-1.40	2.1-2.2	1.09-1.14	.91-.97	.98-1.1	1.2-1.55
Tensile Strength (1000's psi)	10	7-14.5	1.9-8.5	6.5-9.9	7.0-11.0	1.5-5.5	3.5-12.0	1.5-9.0
Compressive Strength (1000's psi)	18	12-18	13-36	1.7-80.	7.2-13.0	2.5-10.	4.8-16.0	1.0-13.0
Impact Strength	Excelt	Excelt	Good	Excelt	Excelt	Excelt	Good	Good
Clarity	Tri-O	T-O	T-O	Tri-O	Tri-O	Tri-O	T-O	T-O
Electrical Resistance	Excelt	Good	Good	Excelt	Excelt	Excelt	Good	Good
Heat Distortion Point (Degrees F.)	338	150-210	115-250	250	300-360	105-230	165-225	100-165
Maximum Service Temp. (Degrees F.)	185-250	140-200	115-200	390-550	175-400	212-320	140-250	115-200
Burning Rate	S	S	S to SE	None	S to SE	S	S	S to SE
Water Absorption Rate	Low	Low	High	None	None	Low	None	Low
Effect of:								
Weak Acids	Attbysome	Little	Little	None	Little	Little	None	Little
Strong Acids	Attacked	Attbysome	Decomp.	None	Attacked	SlAttack	Attbysome	Attbysome
Weak Alkalies	Attbysome	Little	Little	None	None	Little	None	Little
Strong Alkalies	Attacked	Attbysome	Decomp.	None	None	Little	None	
Solvents	None	Solinsome	Solinmany	None	Little	Solinsome	Solins	
Outdoor Conditions (Sunlight)	Little "chalks"	None	Little	None	Slight	Crazes	Discolor	

T-transparent, Tri- translucent, O - Opaque S=slow, SE - self-extinguishing

Addition Polymerization



ETHYANE 7/1/97



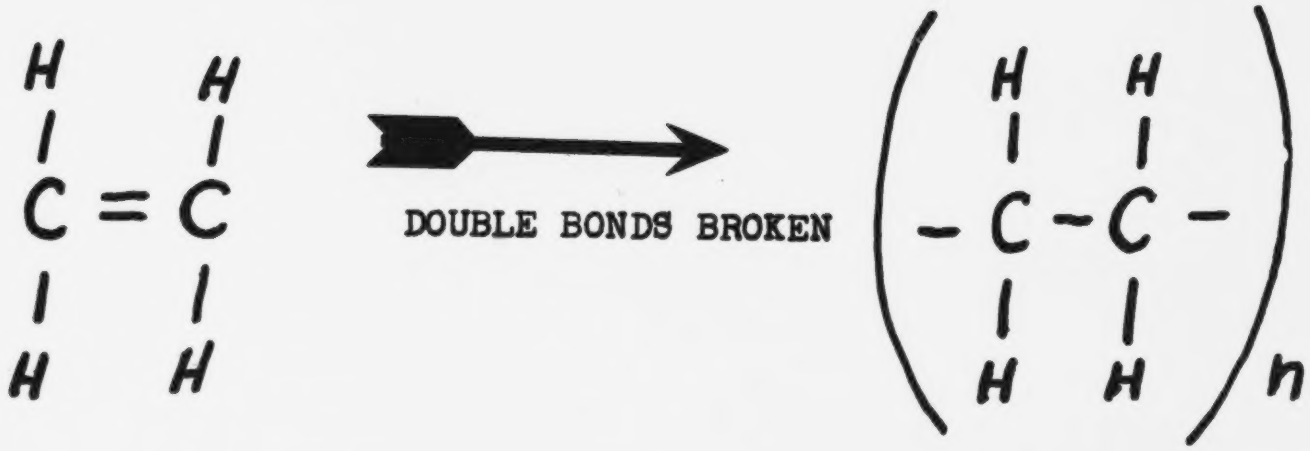
$$\begin{array}{ccc} H & & H \\ | & & | \\ C & = & C \\ | & & | \\ H & & H \end{array}$$

POLYMERIZATION

Polyethylene

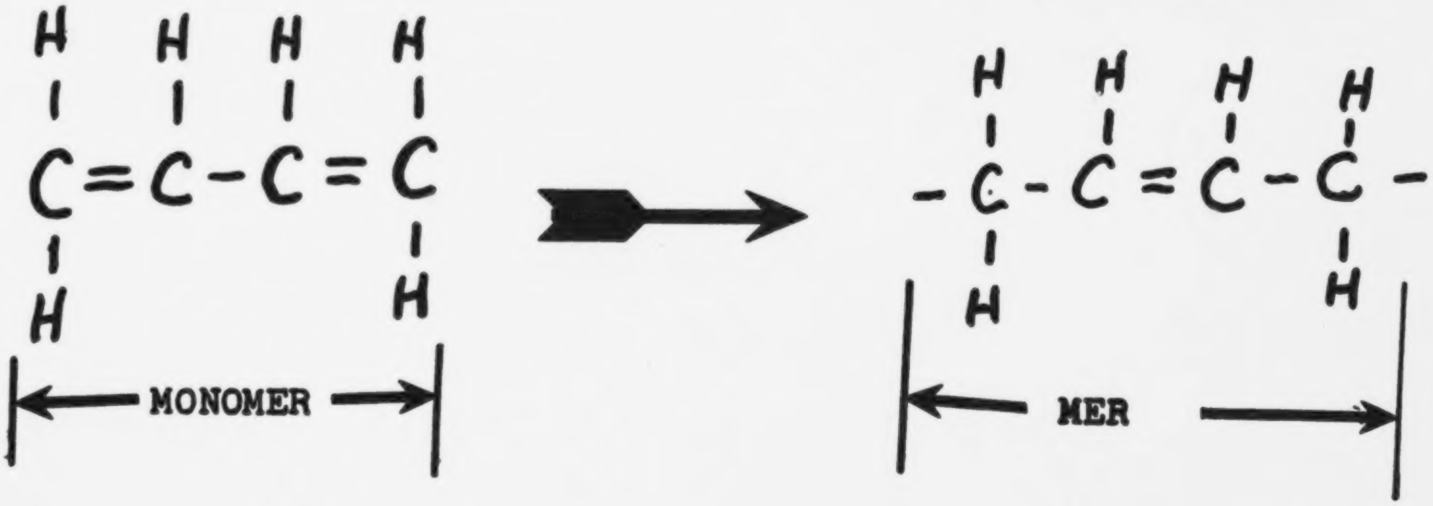
(MANY MOLECULES OF ETHYLENE JOINED TOGETHER)

$$n\left(CH_2=CH_2\right) \xrightarrow[\text{HEAT - LIGHT PRESSURE}]{\text{(CATALYST)}} \left(CH_2-CH_2\right)_n$$



$$\begin{array}{ccc} H & & H \\ | & & | \\ C & = & C \\ | & & | \\ H & & H \end{array} \xrightarrow[\text{DOUBLE BONDS BROKEN}]{} \left(\begin{array}{ccccc} & H & & H & \\ & | & & | & \\ - & C & - & C & - \\ & | & & | & \\ & H & & H & \end{array}\right)_n$$

BIFUNCTIONAL
TWO REACTION SITES
FOR OTHER MOLECULES

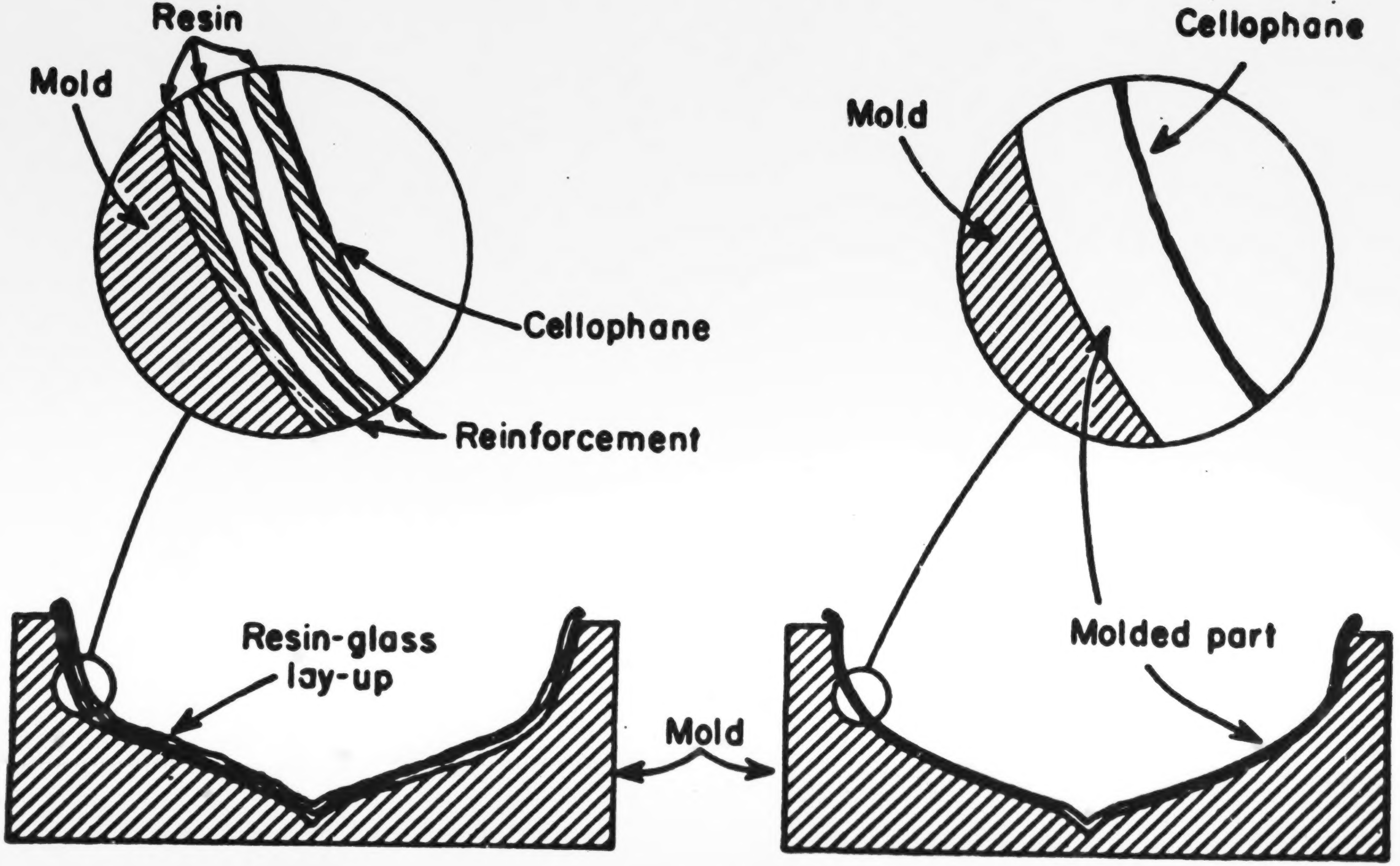


$$\underbrace{\begin{array}{ccccccc} H & & H & & H & & H \\ | & & | & & | & & | \\ C & = & C & - & C & = & C \\ | & & & & & & | \\ H & & & & & & H \end{array}}_{\text{MONOMER}} \longrightarrow \underbrace{\begin{array}{ccccccccc} & H & & H & & H & & H & \\ & | & & | & & | & & | & \\ - & C & - & C & = & C & - & C & - \\ & | & & & & & & | & \\ & H & & & & & & H & \end{array}}_{\text{MER}}$$

POLYMERS ⟶ MANY MERS

ATOMS, SYMBOLS,
VALENCE NO. & STRUCTURE

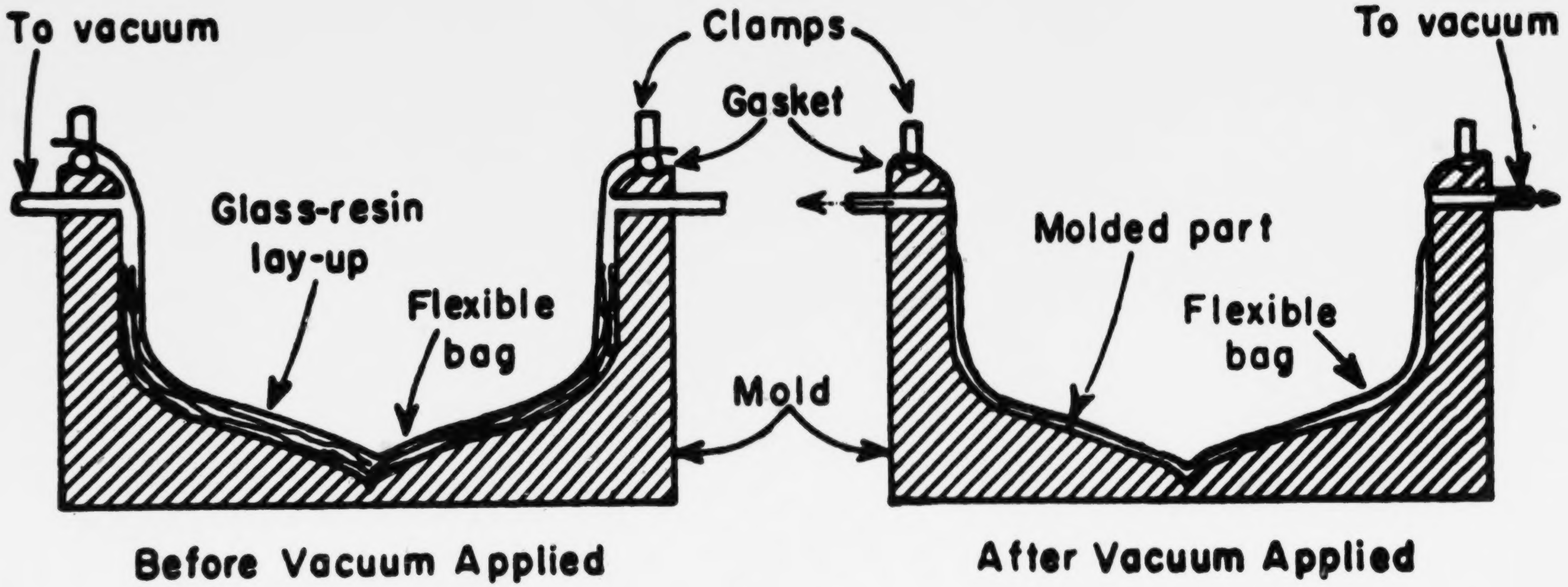
ATOMS	SYMBOL	VALENCE NO.	STRUCTURE
Hydrogen	H	1	$-H$
Fluoride	F	1	$-F$
Chlorine	CL	1	$-CL$
Iodine	I	1	$-I$
Bromine	Br	1	$-Br$
Oxygen	O	2	$-O-$
Sulfur	S	2	$-S-$
Nitrogen	N	3	$-\overset{\mid}{N}-$
Carbon	C	4	$-\underset{\mid}{\overset{\mid}{C}}-$
Silicon	Si	4	$-\underset{\mid}{\overset{\mid}{S}}-$


Resin
Mold
Cellophane
Reinforcement
Resin-glass lay-up
Mold
Cellophane
Mold
Molded part

During Lay-up

After the Cure

FIG. 11-6. Contact molding process.


To vacuum
Clamps
Gasket
To vacuum
Glass-resin lay-up
Flexible bag
Molded part
Flexible bag
Mold

Before Vacuum Applied

After Vacuum Applied

FIG. 11-7. Vacuum-bag molding process.

Matched-die Molding. Matched-die molding

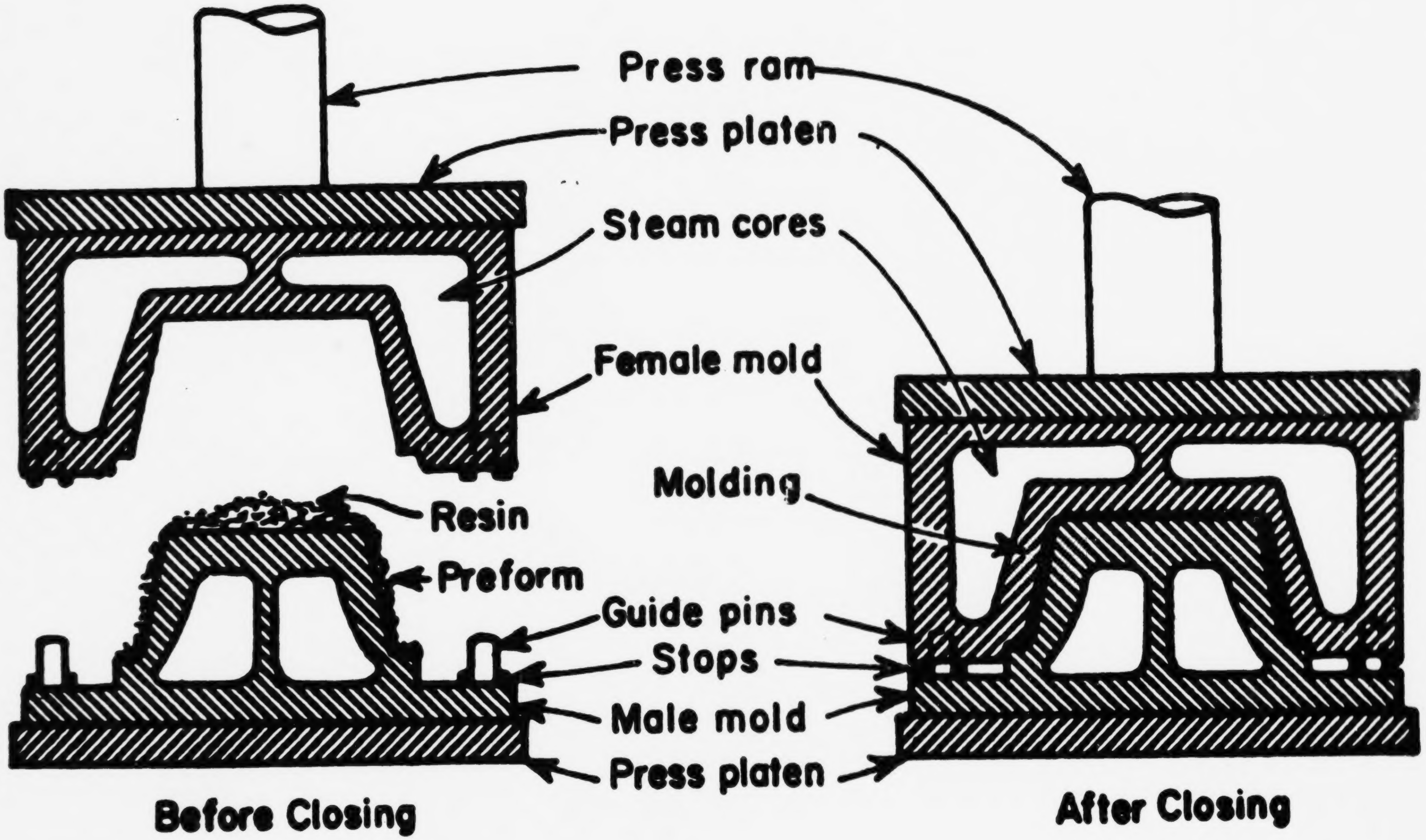

Press ram
Press platen
Steam cores
Female mold
Molding
Resin
Preform
Guide pins
Stops
Male mold
Press platen
Before Closing
After Closing

FIG. 11-8. Matched-die molding process.

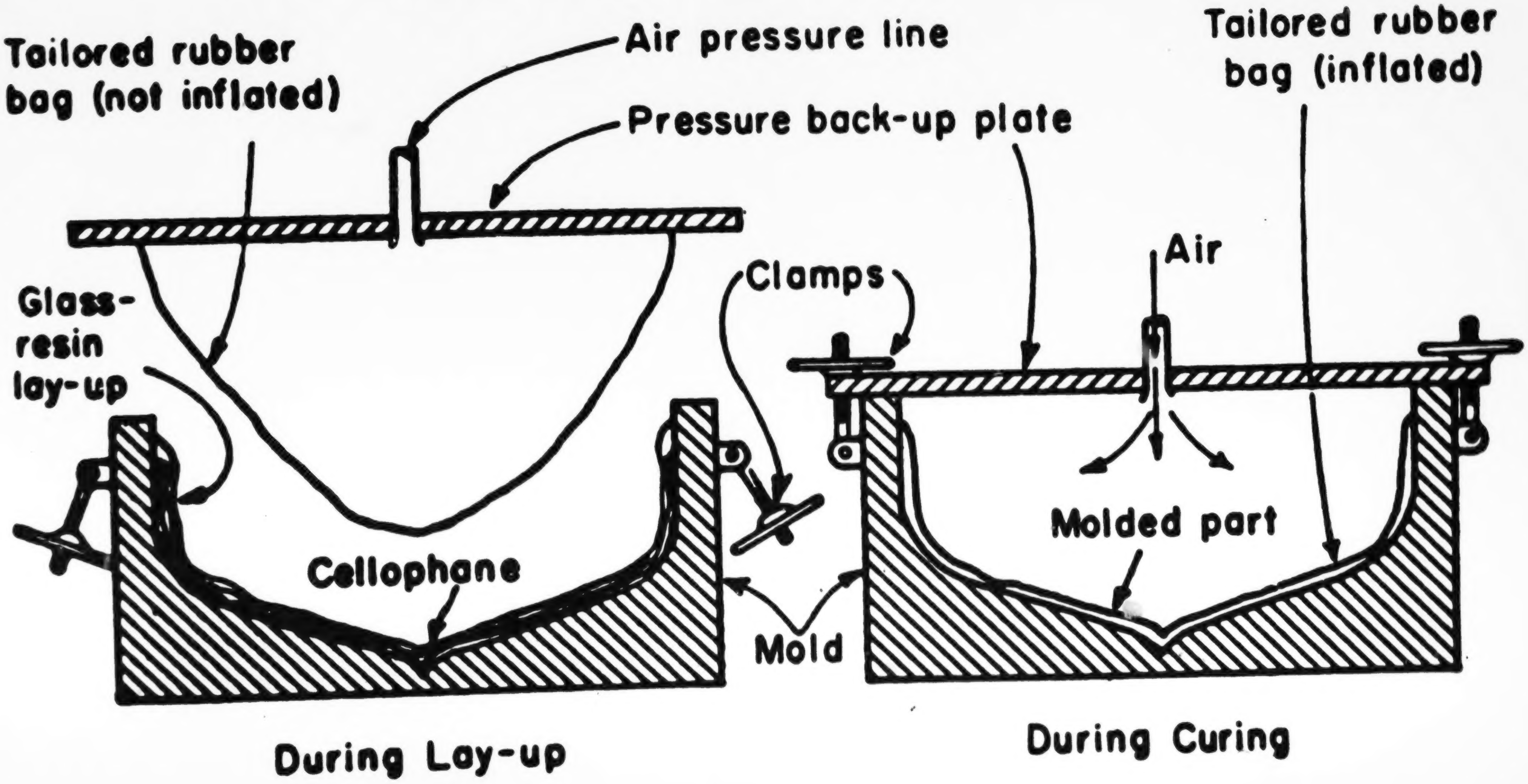
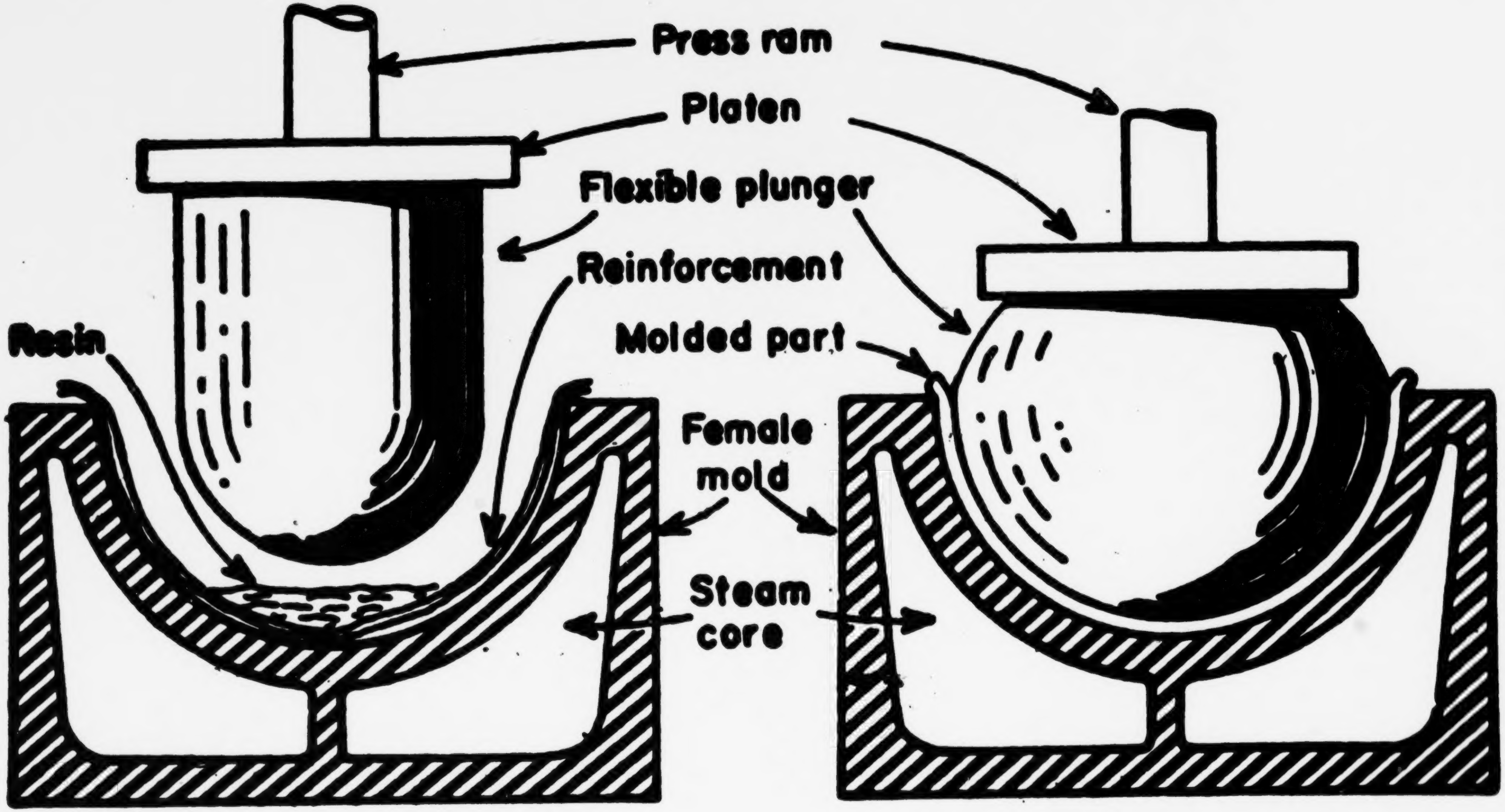

Tailored rubber bag (not inflated)
Air pressure line
Pressure back-up plate
Tailored rubber bag (inflated)
Air
Glass-resin lay-up
Clamps
Molded part
Cellophane
Mold
During Lay-up
During Curing

FIG. 11-9. Pressure-bag molding process.

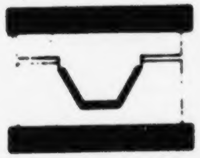
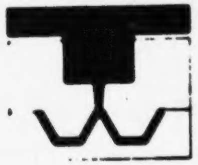
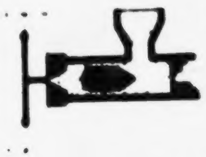

Press ram
Platen
Flexible plunger
Reinforcement
Resin
Molded part
Female mold
Steam core

Before Pressure Applied

After Pressure Applied

FIG. 11-10. Flexible-plunger molding process.

TABLE 5
SUMMARY OF PROCESS FACTS

Process	Temperature Requirements (degrees F.)	Typical Force Required (psi)	Type of Shaping Device	Physical State of Plastic (Entering Process)	Physical State of Plastic (During Process)	Physical State of Plastic (Conclusion of Process)	Type of Plastic Used
 **COMPRESSION MOLDING**	Mold— 280 to 380	2,000 to 15,000	Matched molds	Solid, powder, or pellet	Liquid, or soft solid	Solid	Thermosets usually, or thermoplast
 **TRANSFER MOLDING**	Transfer chamber and mold— 280 to 380	6,000 to 12,000	Closed mold, sprue to transfer chamber	Solid, powder, or pellet	Liquid	Solid	Thermoset
 **INJECTION MOLDING**	Cylinder— 300 to 650, mold— 100 to 140	5,000 to 40,000	Closed mold, connection to injection nozzle	Solid	Liquid	Solid	Thermo-plastics
EXTRUSION	Cylinder 300 to 500	500 to 6,000	Die opening shaped to cross section of extrudate	Solid	Liquid	Solid	Thermo-plastics
BLOW MOLDING	Mold— cold to 200 parison— 300 to 500	40 to 100	Hollow split mold	Soft solid	Soft solid	Solid	Thermo-plastics
CALENDERING	Rolls— 300 to 400	Force depends on viscosity, roll length. and diameter	Pairs of smooth or patterned rolls	Liquid	Liquid	Solid	Thermo-plastics

POLYESTER Pattern of consumption

Market	**1966 million lb.**	**1967 million lb.**
Export	11.8	9.2
Reinforced plastics Sheet, flat and corrugated	40	45
All other	252.7	268.1
Surface coatings	6.5	9.2
All other uses[a]	96	111.2
Total	**407**	**442.7**

[a] —Includes body putty, buttons, cultured marble, and clay pipe seal.

REINFORCED PLASTICS

Pattern of consumption[a]

Market	1967 million lb.	1968 million lb.
Aircraft, aerospace	47	45
Appliances	16	20
Boats & accessories	110	120
Construction	105	110
Consumer products	55	58
Containers, trays, industrial housings	22	24
Electrical	25	30
Pipes, ducts, tanks	40	47
Transportation	110	122
Miscellaneous	30	35
Total	**560**	**611**

a—Table includes, for the first time, glass and resin for both thermoplastics and thermosetting composites.

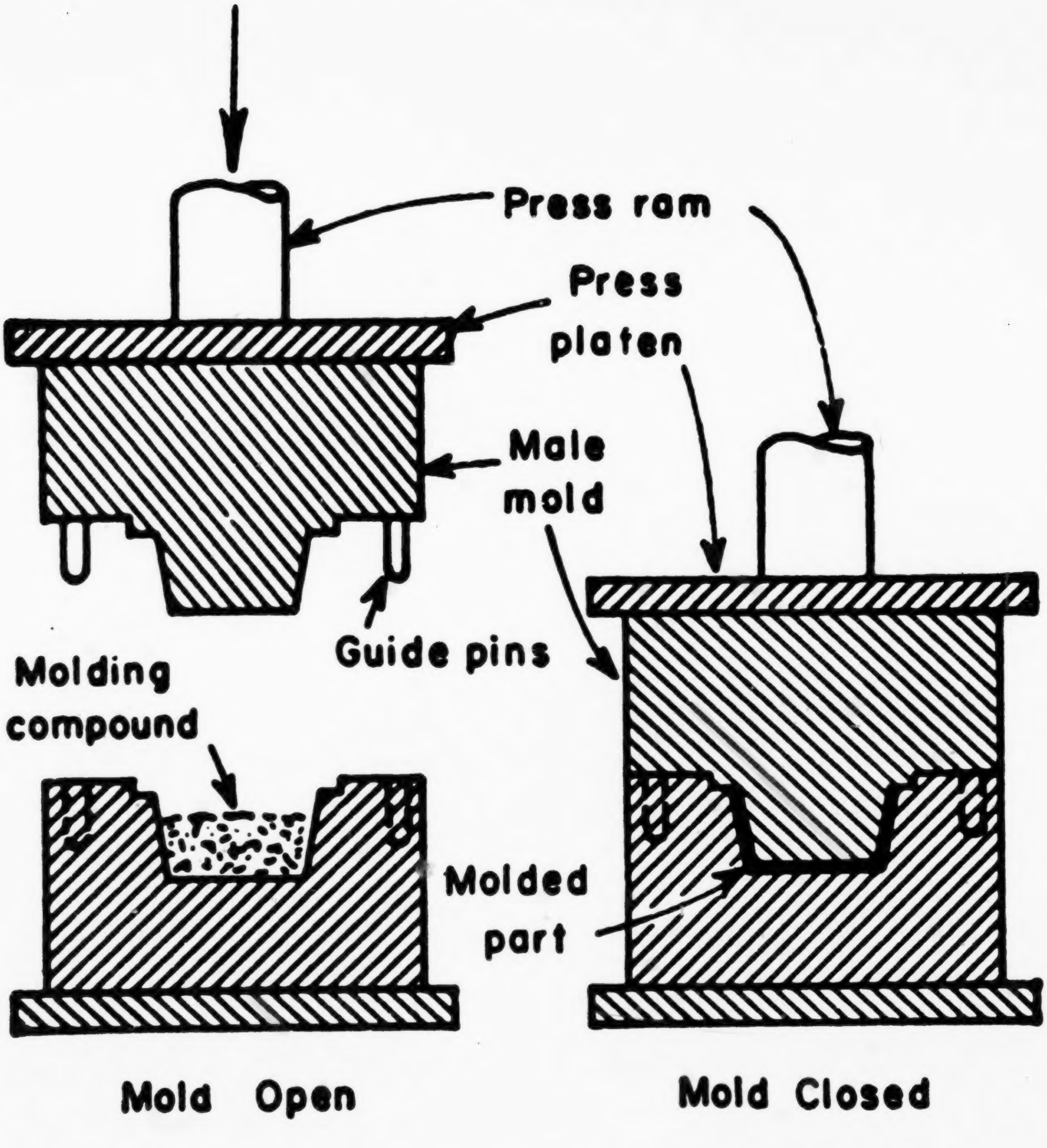

Press ram
Press platen
Male mold
Guide pins
Molding compound
Molded part
Mold Open
Mold Closed

FIG. 11-11. Compression molding process.

Western processing capacity by type of equipment[a]

	Injection molding machines	Blow molding[b] machines	Thermo-forming machines	Compression & transfer presses	RP molding presses	Coaters	Extruders	Calenders
Arizona	50	N[c]	5	30	N	N	5	N
California	2000	300	250	1000	100	250	450	30
Colorado	100	N	10	50	10	10	20	1
New Mexico	25	N	N	20	N	N	N	N
Oregon	125	N	15	125	25	50	35	1
Utah	40	N	N	25	N	N	N	N
Washington	200	20	35	200	35	75	50	N
Other Western states[d]	20	N	N	5	N	N	N	N

a—Source: MODERN PLASTICS survey of 3000 Western processors and fabricators.
b—Excludes extruders. c—Negligible, less than 5 units. d—Idaho, Montana, Nevada, and Wyoming.

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: Joseph Braco
State University College
Oswego, New York

INSTRUCTIONAL LEVEL: College

TITLE: Properties of Polymers

PRESENTATION TIME: 1 1/2 hours

INTRODUCTION:

1. Plastics have proved to be the answer to many engineering problems because of their outstanding favorable properties.
    a. Self lubricating bearings in foods and textile machinery.
    b. Grit-resistant bearings in rock crushers.
    c. Tubing which is flexible at cryogenic temperatures
    d. Lightweight, high-strength films in space satellites.
    e. High-strength radomes produced virtually without tooling.
2. Plastic parts require a minimum of finishing after processing.
3. They can have integral color, glass or textured finish imparted during molding or forming.
4. A single plastic molding may replace an assembly of several metal parts.
5. Because of their combinations of properties, plastic parts may provide several functions.
6. As a result, the cost of a plastic part tends to be lower than a comparative per pound or per cubic inch price would indicate.

OBJECTIVES:

1. To understand the general properties of polymers.
    a. Tensile strengths
    b. Thermal properties
    c. Electrical properties
    d. Physical properties
    e. Chemical properties
2. To show the general relationship between plastics and metals.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Polymers

INTER-RELATION WITH OTHER SUBJECTS:
Chemistry, Physics, Social Sciences

MATERIALS AND EDUCATIONAL MEDIA:

1. General Outline
2. Transparencies
3. Charts
4. Samples
5. Movies
    a. Plastic Tooling and Pattern-making with Epoxical Resins, U.S. Gypsum Company.
    b. Origin and Synthesis of Plastics Materials, Visual Educational Department, U.S. Office of Education.
6. Experiments
    a. Check hardness of various polymers
    b. Check tensile strengths of polymers
    c. Check heat and electrical conductivity
    d. Pour various mixes using varying amounts of plasticizers.
7. Take field trips to neighborhood plants
8. Study the polymers utilized in car construction
9. Have guest speakers in to talk about this field
10. Work with the chemistry department
11. Hand out ditto sheets, "Properties of Polymers"

PRESENTATION:

Synthetic polymers now available already possess several of the properties required of a structural material. The major drawback has to do with costs. Time will tell if these polymers can be made inexpensively enough to compete with the traditional materials such as wood, metal and ceramics.

Some of the properties of polymers that make them so desirable are:

Physical Properties

1. Weight - relatively light, some float (trans. C-1)
2. Hardness -
    a. Not very hard. Hardness comparable to brass and aluminum.
    b. Thermosets are harder than thermoplastics.
    c. Temperature affects hardness - high temperatures soften most plastics.

3. Tensile strength -
    a. Polyesters reinforced with fiberglass go up to 100,000 p.s.i. (trans. C-2)
    b. Many unreinforced polymers reach 5,000 to 10,000 p.s.i.
    c. Some polymers stretch five times their normal length before breaking.
    d. Steel elongates only .1%.
4. Compressive strength -
    a. Polyesters resist forces up to 70,000 p.s.i.
    b. Typical values are about 20,000 to 25,000 p.s.i.
    c. Aluminum has 12,000 and steel has about 50,000 p.s.i.
5. Impact strength - Epoxies and polyesters have higher impact strengths than steel.
6. Creep and cold flow -
    a. All polymers exhibit some creep.
    b. Thermoplastics creep at a greater rate than thermosets.
7. Dimensional stability -
    a. Polymers do not generally expand and contract with the addition or loss of moisture as does wood.
    b. Most polymers exhibit very high dimensional stability.
8. Damping - Polymers are quite vibration absorbent. About 10 times more than steel.
9. Optical Properties -
    a. The majority of resins are clear, transparent and colorless in their natural state
    b. Acrylics and polystyrene possess greater clarity than most glass, transmitting about 90% of the light falling upon them.

Electrical Properties (trans. C-3)

Dielectric strength - Nearly all polymers when dry are excellent insulators.
Dielectric Constant - Most polymers are very high. With air as 1, most polymers range between 2.5 and 7.
Arc resistance - No organic polymers are exceptional in this area. Where severe arcing is likely to occur, other materials are used.

Thermal Properties

1. Thermal Conductivity -
    a. Copper transmits over 200 times as much heat as most polymers. Cast iron 250 times; wood about twice as much.

        - b. This property makes polymers pleasant to the touch, even on hot pans or on refrigerator units.
    2. Thermal Expansion - Generally very high for most polymers.
    3. Heat Resistance -
        - a. Generally, polymers are quite low in heat resistance.
        - b. Some epoxies and silicones will withstand temperatures around 400 to 600° F.
        - c. Some phenolics can go up to 5000° F. for brief periods of time.
        - d. Usually polymers are ruled out where high temperatures are required.
    4. Fire Resistance -
        - a. Many polymers can be ignited with an open flame.
        - b. Some burst into flame with just an elevated temperature.
        - c. Few polymers are used where they come into direct contact with fire.
    5. Resistance to cold -
        - a. Polymers, generally have very good resistance to cold temperatures.
        - b. Some fluorocarbons can be used at minus 300° F.

Chemical Properties

1. Resistance to Acids -
    - a. Most are extremely resistant to acids.
    - b. Almost none are affected by fruit and vegetable juices.
    - c. The fluorocarbons are the most resistant to the effects of acids.
2. Resistance to Alkalies -
    - a. Most polymers are very resistant to alkalies.
    - b. About half of the polymers are completely resistant to the very strong alkalies.
    - c. The cellulosic, melamines and casein polymers are decomposed by strong alkalies.

UNIT EVALUATION:

1. Short tests on the various properties
2. Experiments on the properties
3. Class discussion and general interest
4. Behavior changes that actually take place with each individual. Ex: He talks, discusses, reads, experiments with these properties.

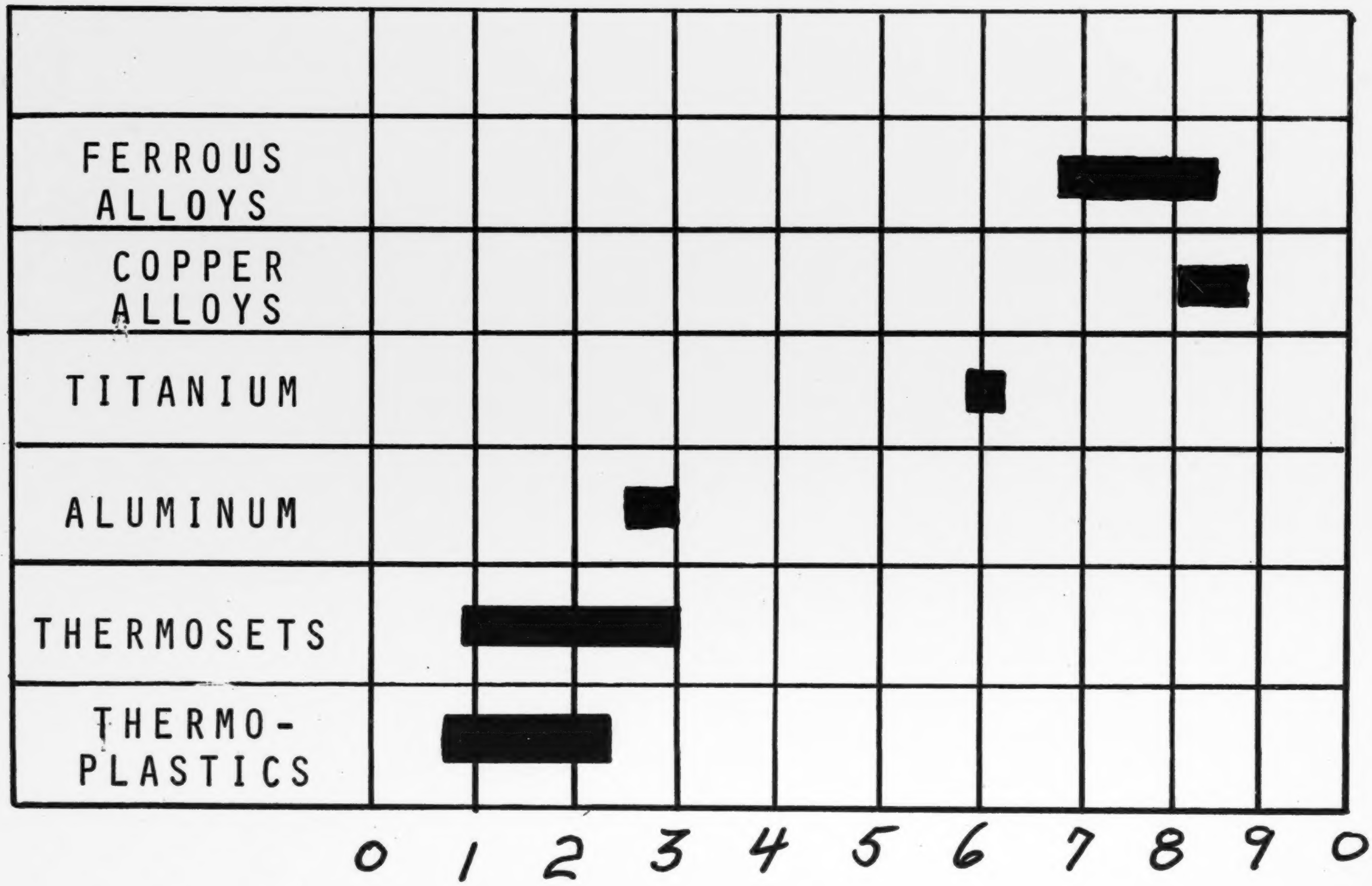
DEFINITION OF TERMS:

1. Compressive Strength - the ability of a material to resist crushing.
2. Creep and Cold Flow - change in dimension when material is subjected to stress. Cold flow is a form of creep which occurs at room temperature.
3. Damping - the property of resisting the transmission of vibrations.
4. Dielectric Constant - the measure of a materials usefulness as an insulating element in a capacitor.
5. Dimensional Stability - general properties which covers shrinkage and warpage.
6. Fatigue - the general behavior of materials under constant cycles of loading and unloading.
7. Hardness - the resistance to the breaking of a surface with a given load.
8. Impact - ability to resist sharp, sudden blows or shocks.
9. Optical Property - ability to allow light rays to pass through a material.
10. Tensile Strength - ability of a material to resist a pulling force.
11. Thermal Conductivity - a measure of its ability to conduct heat or cold.
12. Thermal Expansion - the increase in size, length, area or volume during temperature rise.

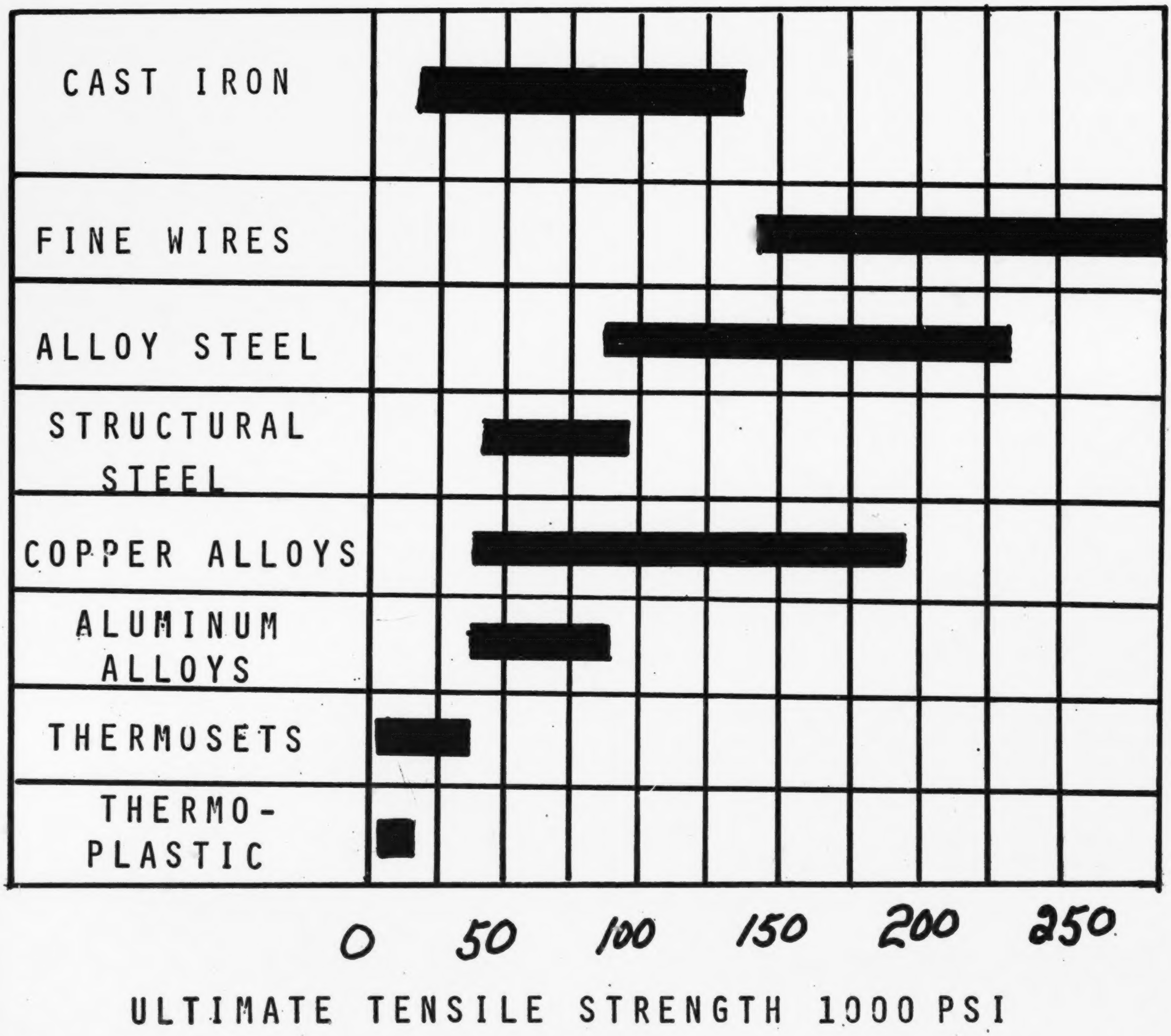
REFERENCES:

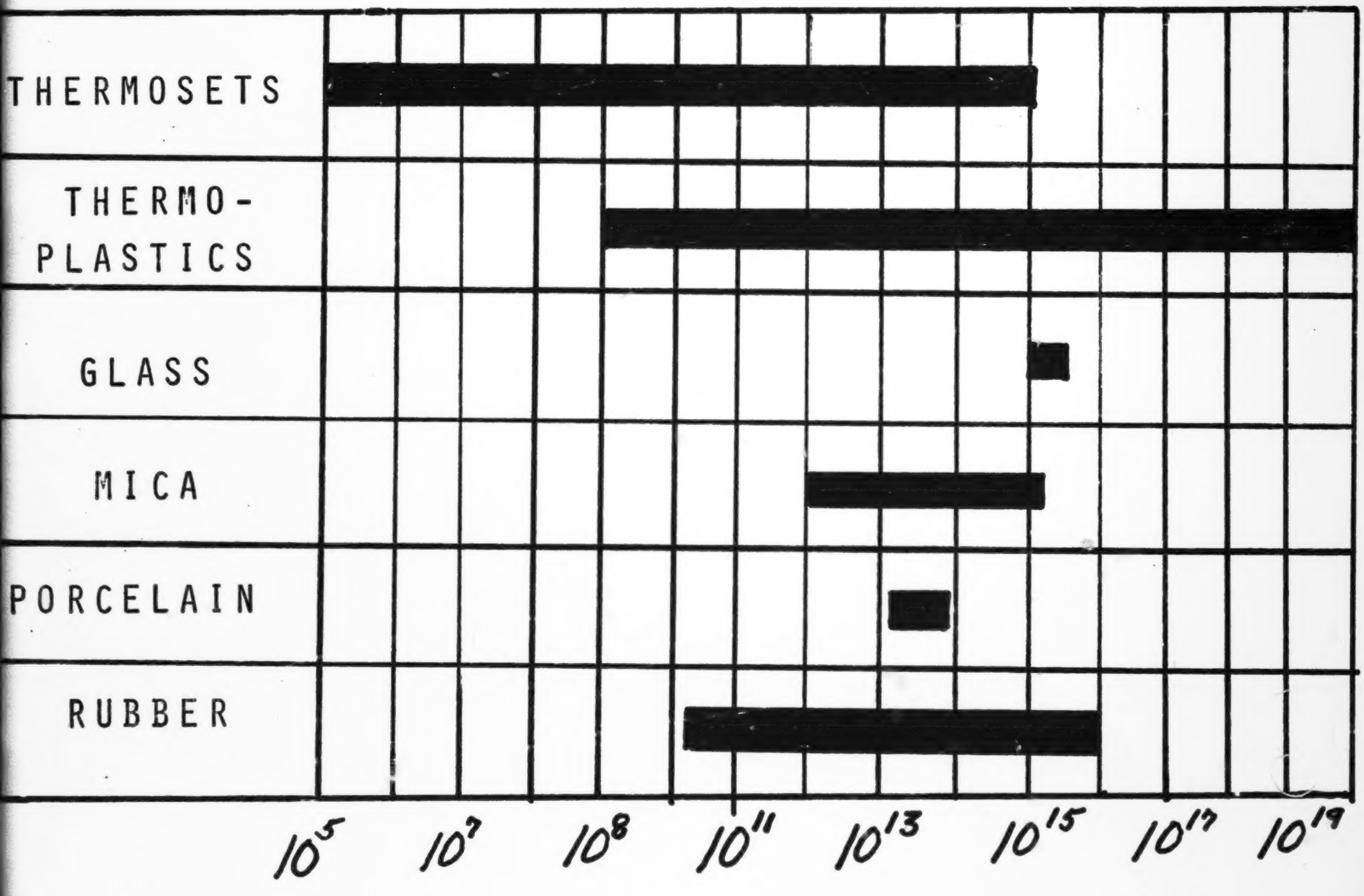
1. ASTM Standards, American Society for Testing Materials.
2. Plastics Technology, Swanson, McKnight and McKnight.
3. Engineering Materials Handbook, Mantell, McGraw-Hill.
4. Modern Plastics Encyclopedia, Breskin Publication, Boistal, Connecticut.
5. Scientific American
6. The Story of the Plastics Industry, The Society of the Plastics Industry, New York, New York.
7. Machine Design (Plastics Issue), Penton Publishing Co.

NUMBER	POLYMER CHARACTERISTIC	EXAMPLES	USES
1	flexible and crystallizable chains	Polyethylene Polypropylene Polyvinyl Chloride Nylon	rails, pipes, thin films, steering wheels, plastic pipes, stockings, shirts, clothing
2	cross-linked amorphous networks of flexible chains	Phenol Formaldehyde Cured rubber Styrenated Polyesters	television cabinets, telephone receivers, tires, hoses, belts, finish on autos and appliances
3	rigid chains	Polyamides Ladder molecules	high temperature insulation, heat shields
4	crystalline domains in a viscous network	Neoprene Polyisoprene	oil-resistant rubber, particularly resiliant rubber goods
5	rigid chains partly cross-linked	heat resistant materials	jet and rocket parts
6	crystalline domains with rigid chains between them and cross-linking between them	materials of high strength and temperature resistance	buildings and building materials and vehicles

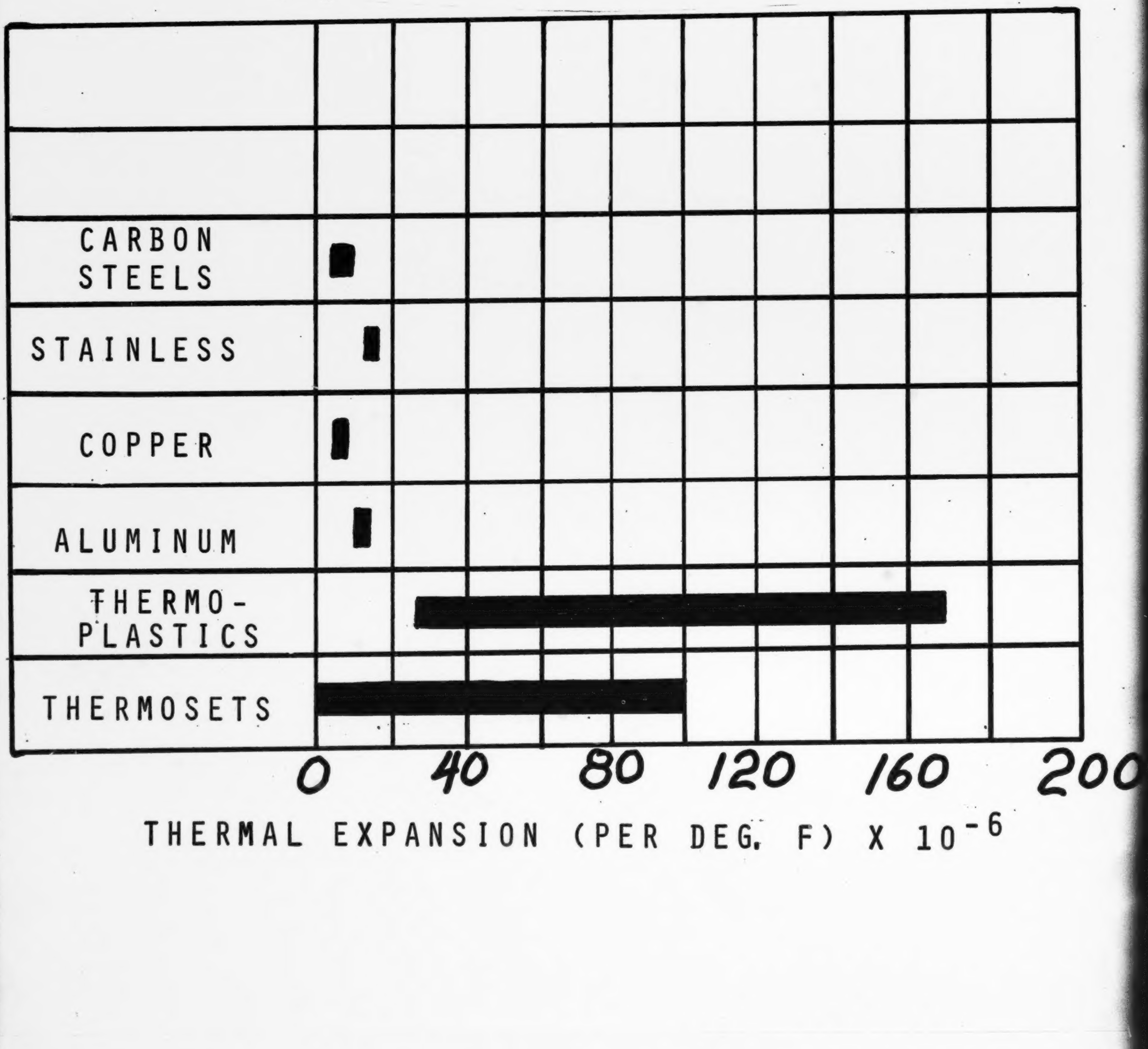


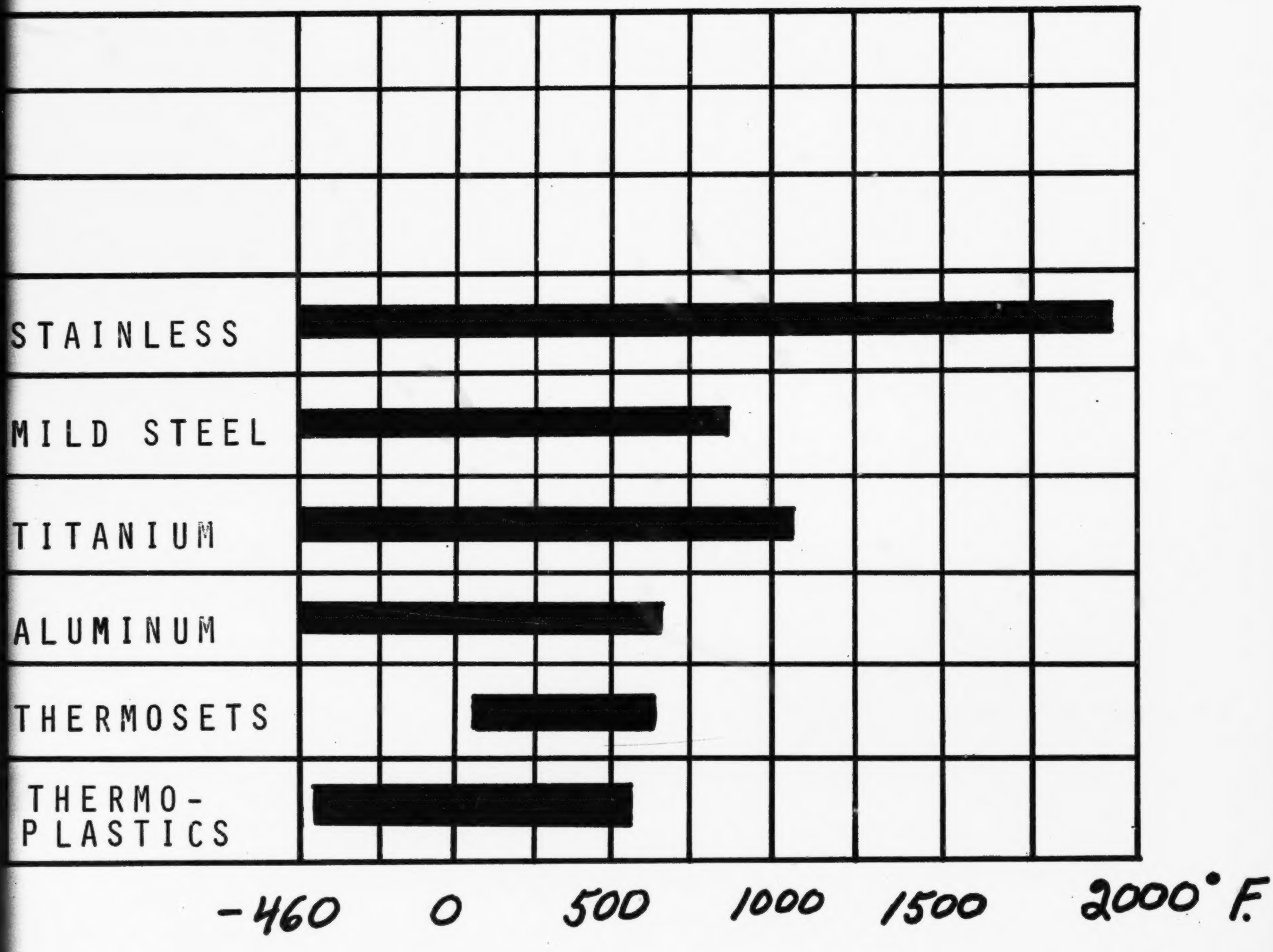
SPECIFIC GRAVITY


CAST IRON
FINE WIRES
ALLOY STEEL
STRUCTURAL STEEL
COPPER ALLOYS
ALUMINUM ALLOYS
THERMOSETS
THERMO-PLASTIC
0
50
100
150
200
250
ULTIMATE TENSILE STRENGTH 1000 PSI



RESISTIVITY (OHMS-CM)

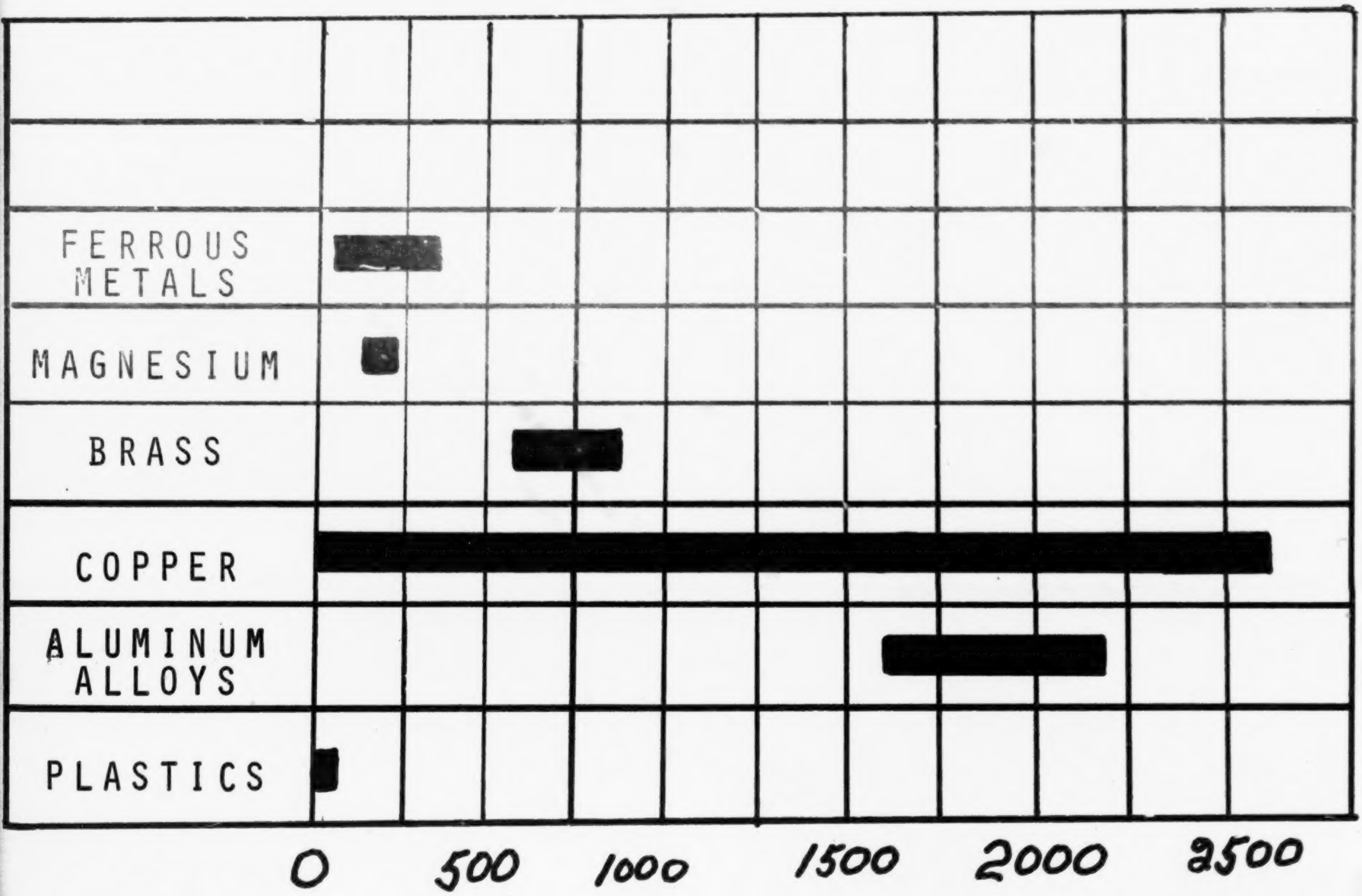

CARBON STEELS
STAINLESS
COPPER
ALUMINUM
THERMO-PLASTICS
THERMOSETS
0
40
80
120
160
200
THERMAL EXPANSION (PER DEG. F) X 10^{-6}



USEFUL TEMPERATURE RANGE (F)

THERMAL CONDUCTIVITY

(BTU - IN./HR. - SQ. FT. - DEG. F)



SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: Joseph Braco
State University College
Oswego, New York

INSTRUCTIONAL LEVEL: College

TITLE: Structure and Composition of Polymers

PRESENTATION TIME: 1 1/2 hours

INTRODUCTION:

Our modern society depends fundamentally on organic polymers, which provide our necessities of life. In order to have a basic understanding of this important material, a study of what makes up these polymers is of paramount importance. Every use of materials, no matter how trivial, involves selection. It is possible through understanding or experiment to maximize any one property but in no application is it possible to select a material for one property alone. It is the balance of one factor against another that the material's engineer finds his challenge and his satisfaction.

It was not until the Twentieth Century that some of the powerful instruments like the ultracentrifuge, electron microscope, viscometer, osmometer, diffusion cell and x-ray diffraction apparatus were used to reveal the polymers in all their intricacy. The molecules were discovered to be incredibly large. The molecular weights ran as high as millions of units, whereas simple organic substances such as sugar and gasoline have molecular weights in the range of 50 to 500 units. The giant molecules turned out to be composed of a large number of repeating units. They were consequently given the name "polymer;" from the Greek words "poly" (many) and "meras" (parts), and the building blocks were called monomers. Most polymers were found to have the long, flexible chains. Packed side by side in a bundle, the molecules formed a regular array with a crystalline structure. Examination of natural polymeric materials showed that their structure was partly crystalline and partly amorphous. If the crystalline structure predominated, the material was relatively strong, rigid and resistant to heat and dissolution; if the substance was amorphous, the substance was soft, elastic, absorptive and permeable to fluids. (trans. B-1)

OBJECTIVES:

1. To have a basic understanding of what is meant by linking and crosslinking.
2. To have an understanding of polymer composition.
3. To understand the structure of polymers.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Polymers

INTER-RELATION WITH OTHER SUBJECTS:

1. Chemistry
2. Electricity, Electronics
3. Woodworking
4. Textiles
5. Metals
6. Ceramics

USE IN INDUSTRY:

In a little over a half century, our world and society has been transformed from a horse and buggy era to our highly technological society of today. Much of this has been possible because of the research and developments in the study of structure and composition of matter, which polymers have played a very important part in.

MATERIALS AND EDUCATIONAL MEDIA:

1. Transparencies as noted (trans. B-2)
2. Models of basic structures (styrofoam balls)
3. Films
   a. Physical Chemistry of Polymers
   b. Design of Molded Phenolics
4. Samples of various polymer materials
   a. Construction type foam
   b. Regular styro-foam
   c. Phenolics
   d. Vinyls

THINGS TO DO:

1. Examine polymer structures under microscope.
2. Experiment with plasticizers to get varying degrees of flexibility.
3. Watch films on this subject.
4. Do additional readings.
5. Take field trips.
6. Examine products made from polymers

7. Name as many polymers as you can.
8. Ask parents about clothing made from the polymers materials.

PRESENTATION:

The structure of monomers are basically quite simple, but become very complex when different materials are formed by polymerization (trans. B-3)

In synthesizing long-chain molecules, man imitates natural polymers such as cellolose. Today nature is being outdone, and polymers are evolving that may be rigid enough to serve for heavy construction. (show example of construction foam; step on it.)

Thermosets set or hardened under heat into a permanent shape produce an irreversible chemical reaction called cross-linking (polymerization). The reaction links the resin chains into what might be called one giant three-dimensional molecule.

Thermoplastics soften when heated and harden when cooled. Thus for all practical purposes, the major distinction between the two groups is the ability of one material to be formed over and over, while the other can be formed only once. (trans. B-4)

The Thermoset Polymers - The thermosetting materials are generally made from the phenol formaldehyde and phenol furfural materials, the urea formaldehydes, the aniline formaldehydes, the melamine formaldehydes, and to a smaller extent the polyesters and the alkyds. Some of the common thermoset polymers are as follows:

1. Phenol Formaldehyde. This phenolic molding material contains phenolic resins, combined with various fillers which embrace wood flour, cotton floc, chopped paper, fabric, asbestos, mica, silica and glass.

2. Urea Formaldehyde. These usually use alpha cellulose fillers.

3. Melamines. These are usually compression-molded. They usually contain a variety of fillers.

4. Aniline Formaldehyde. These are commonly made without fillers.

5. Furanes. These are commonly made with asbestos fillers.

The Thermoplastic Polymers - The thermoplastic materials normally require plasticizers, which may run from 10 to 70% of the total weight. Some of the most common ones are as follows:

1. Cellulosics. Strong, good electrical insulator, tasteless, non-toxic, full range of colors.

2. Polyamides. Transparent, light diffusion, weather resistant, non-marring, machinable polymers.

3. Vinyls. Easy to form, wear resistant, flexible material.

4. Polyesters. The polyester materials in the uncured state are mixtures of polyesters and polymerized monomers. These polyesters are esters of unsaturated polybasic acids. These esters are dispersed in monomers such as styrene or related materials.

5. Styrenes. These are made from either styrene monomers entirely or copolymerized with other monomers.

6. Polyethylene. These are made by the copolymerization of ethylene under careful controlled pressure and temperature.

Polymer Composition - Most polymers are produced by synthesis from such natural resources as water, air, coal, salt and natural gas. From these are derived the various chemicals and gases which are combined to produce the polymer materials (trans. B-5)

As an example, the raw materials for making polystyrene, one of the most important of the polymers, are coal and petroleum or natural gas. By a process of distillation, benzene is extracted from the coal; from the petroleum or natural gas is taken the gas ethylene. These two materials are linked together to form ethyl benzene which is dehydrogenated to form styrene. With the aid of catalysts heat and pressure, thousands of styrene molecules polymerize, or link together, to form long chain-like molecules that clump into small granules of crude polystyrene.

These grains are hot worked and cut into small pellets called molding powder, the most common form in which polymers are supplied to fabricators.

Modification of Polymers -

1. Before polymer products are processed, most basic polymer resins can be combined, compounded with any one of a large range of modifying chemicals or reinforcing materials in

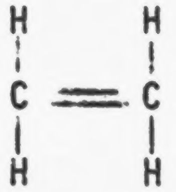
varying proportions to achieve a given end result. Such additions can take the form of plasticizers (which soften the polymer to make it more flexible), stabilizers (which prevent degradation in the polymer when it is exposed to heat or light), fillers (which add bulk and reduce over-all costs), colorants (which add integral color to the processed polymer end product) and reinforcing fibers (which improve impact strength, electrical properties, etc. of finished products.)

2. Solvents are used to give polymers the degree of temporary fluidity necessary to such operations as dipping, brushing, spraying, etc. and catalysts are added to speed up the cure or hardening of the compound.

3. After compounding, the resultant polymers are supplied in convenient liquid, granular or powder from to processors.

Basic Polymer Structure -

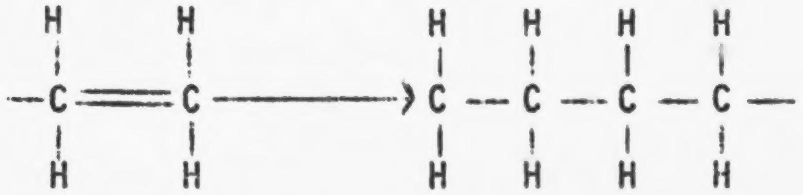
1. A monomer (mono - single, mer - part) is a one part, single molecular unit. Basic building blocks (molecules) joined end to end form polymers. (Show on chalk board or trans.) B-6)



$$H_2C{=}CH_2$$

2. A polymer (poly-many, mer-part) is a giant molecule made up of many parts (single molecules)

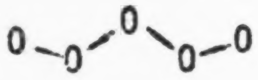
3. Polymerization is the act of combining two or more molecules of a monomer into a single large molecule, thus creating a different substance called a polymer. (Show on chalk board or trans. B-7)



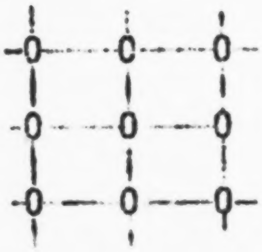
$$-CH{=}CH- \longrightarrow -CH_2-CH_2-CH_2-CH_2-$$

4. A catalyst is a chemical substance which is used in assisting chemical reactions without combining chemically itself.

5. Thermoplastic - long chain-like structure.
(trans. B-8)



6. Thermoset Polymers - cage-like molecular structure.
(trans. B-9)



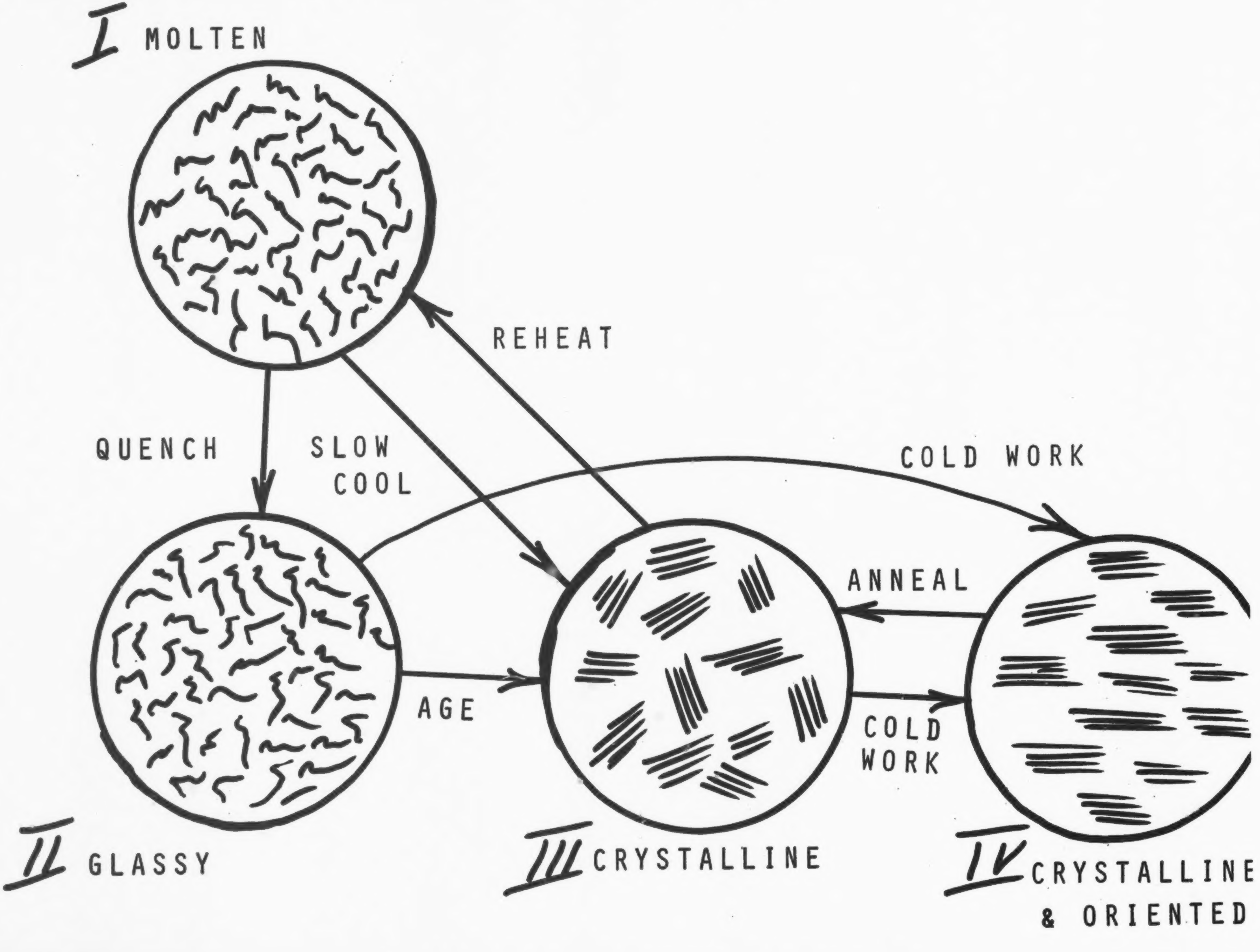
DEFINITIONS OF TERMS:

1. Acetates - The name applied to esters of acetic acid such as ethyl acetate, cellulose acetate, vinyl acetate, etc.
2. Amorphous - Non crystalline and without any long range order.
3. Alloy - A material or substance containing two or more elements.
4. Amides - Organic compounds derived from ammonia and organic acids.
5. Casein - Product obtained from skimmed milk which is the base from which casein plastics are made.
6. Cellulose - The important structural building material of all vegetation.
7. Olefins - Unsaturated hydrocarbons characterized by having two adjacent carbon atoms linked by double bonds.
8. Plasticizer - An additive to commercial resins to produce plasticity.
9. Polyethylene - Derived from the polymerization of ethylene.
10. Polystyrene - The solid (polymer) made from styrene (monomer)
11. Propylene - An unsaturated hydrocarbon containing three carbon atoms.
12. Resinoids - The class names given to thermosetting resins.
13. Styrene - An organic compound derived from coal tar and natural gas which is the monomer from which polystyrene is made.
14. Thermoplastic - A plastic material which is permanently fusible and soluble.

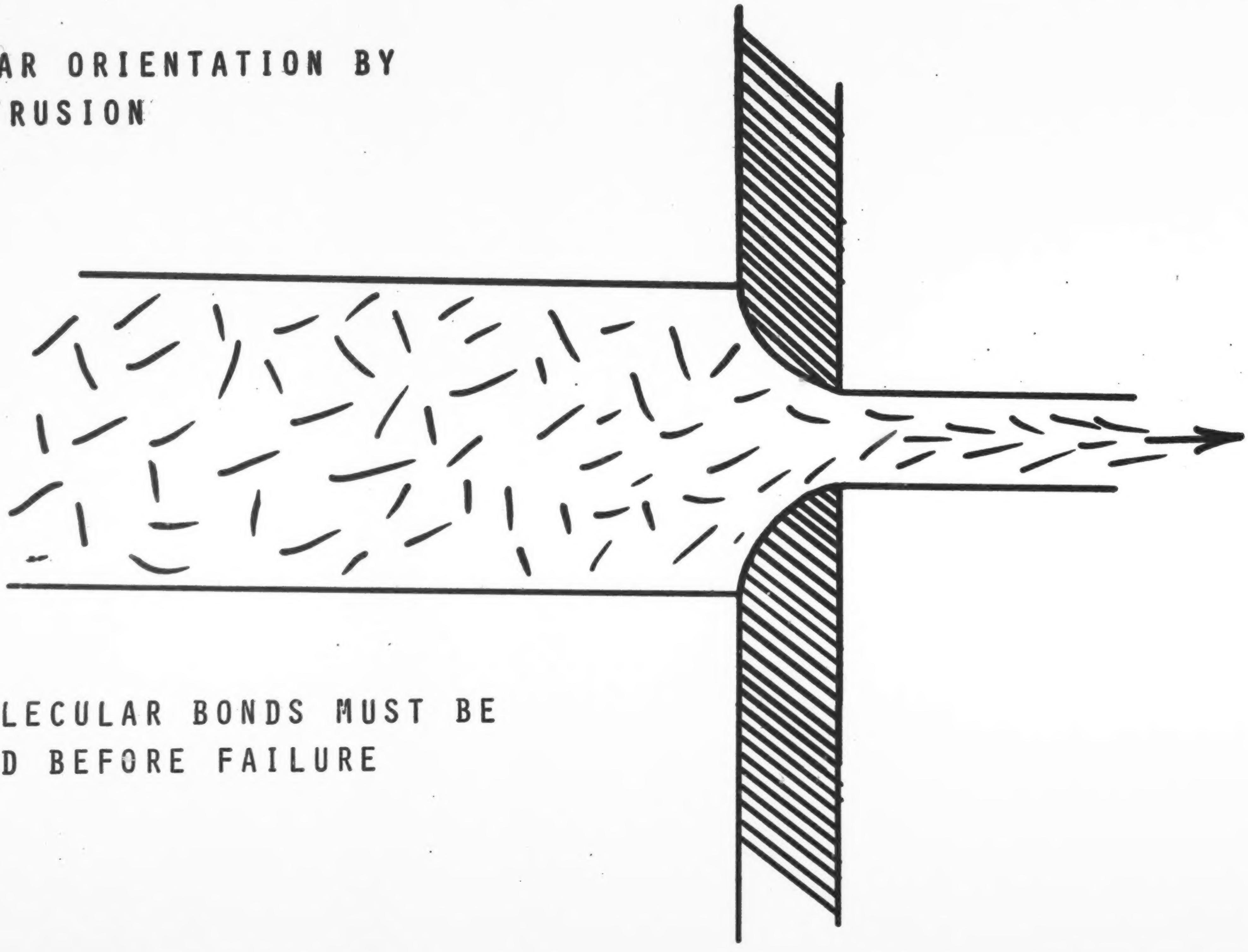
15. Thermosetting - The name given to plastic materials which can be transformed to this infusible insoluble state under the influence of heat.
16. Urea - An organic compound containing nitrogen, made by the action of ammonia on carbon dioxide under pressure.

REFERENCES:

1. 1967 Book of ASTM Standards, Part 26, American Society for Testing and Materials.
2. Engineering Materials Handbook, Mantell, McGraw-Hill.
3. Modern Plastics Encyclopedia, McGraw-Hill.
4. Materials Handbook, Brady.
5. Elements of Material Science, Van Vlack, Addison-Wesley Publishing Co, Inc.
6. Plastics Technology, Swanson, McKnight & McKnight.

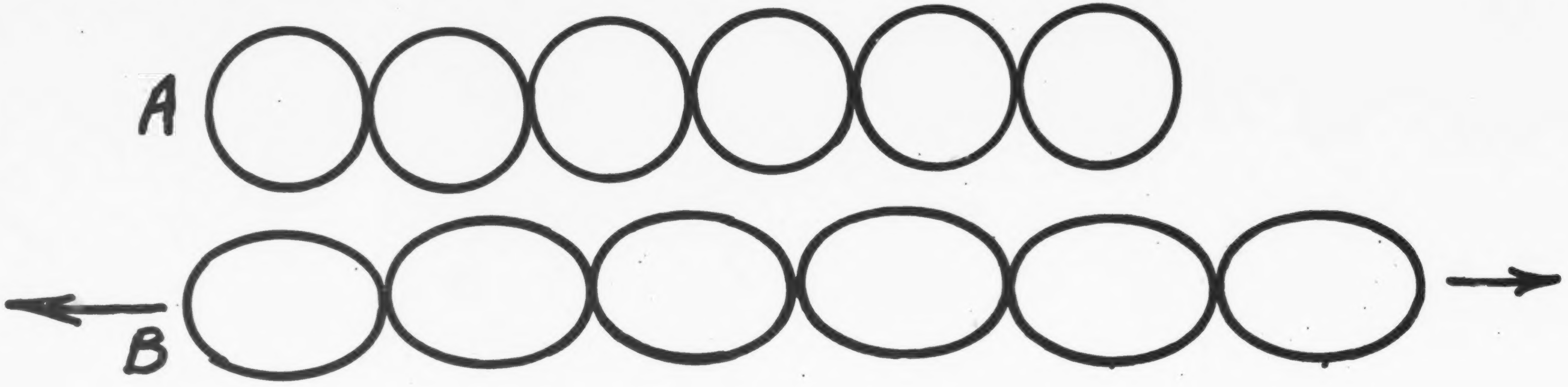

I MOLTEN
REHEAT
QUENCH
SLOW COOL
COLD WORK
ANNEAL
AGE
COLD WORK
II GLASSY
III CRYSTALLINE
IV CRYSTALLINE & ORIENTED

MOLECULAR ORIENTATION BY EXTRUSION

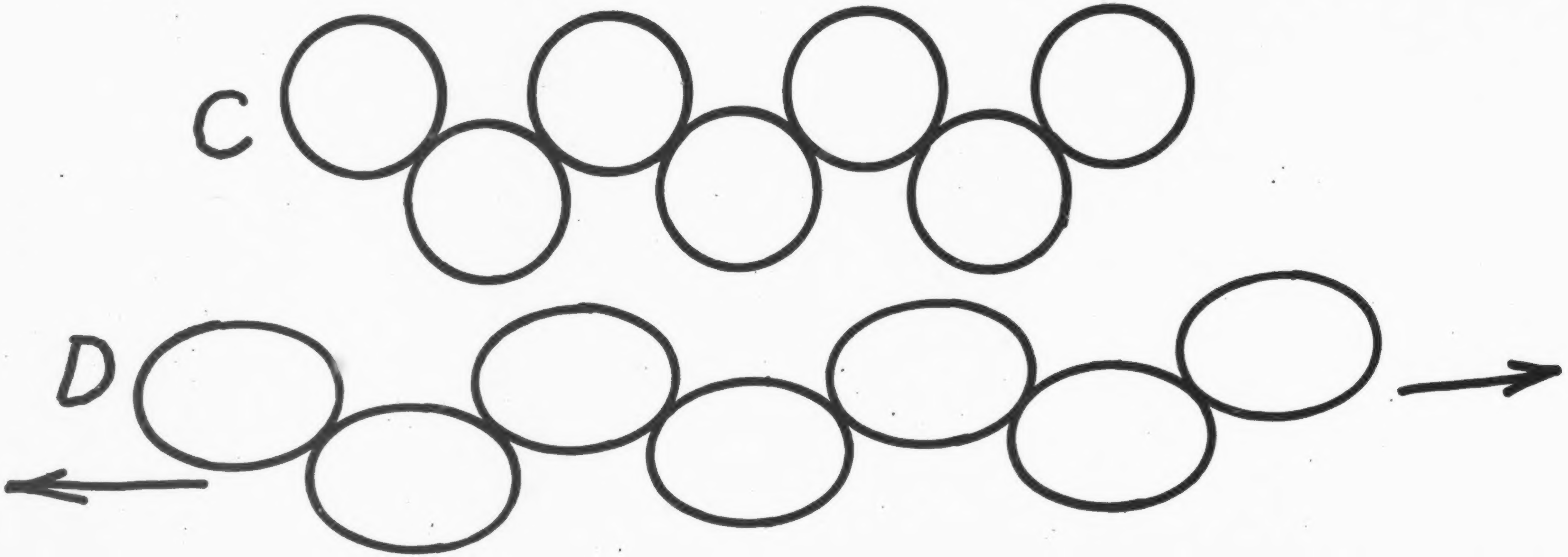


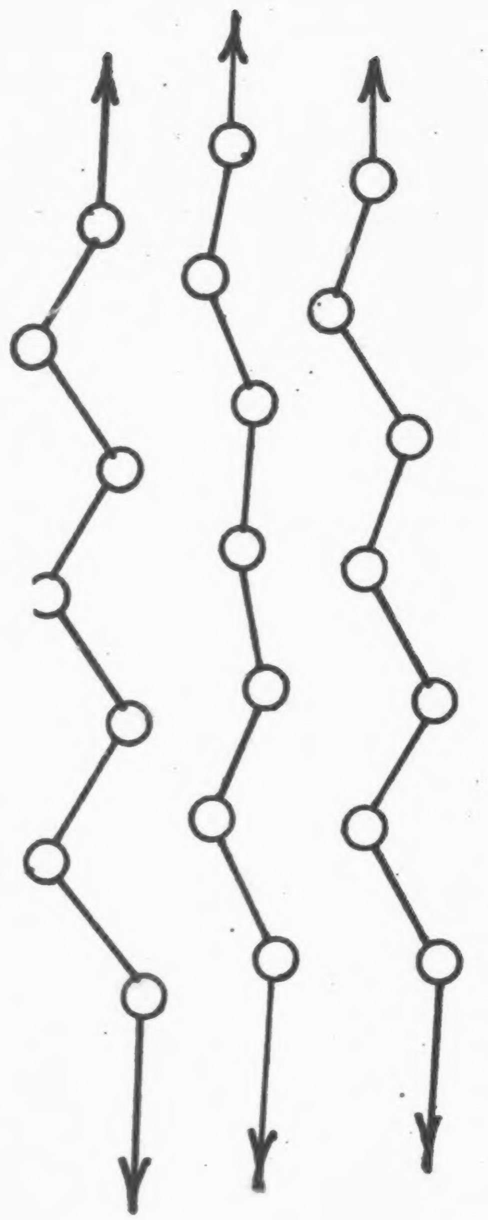
INTRAMOLECULAR BONDS MUST BE RUPTURED BEFORE FAILURE

POLYMER DEFORMATION BY BOND LENGTHENING



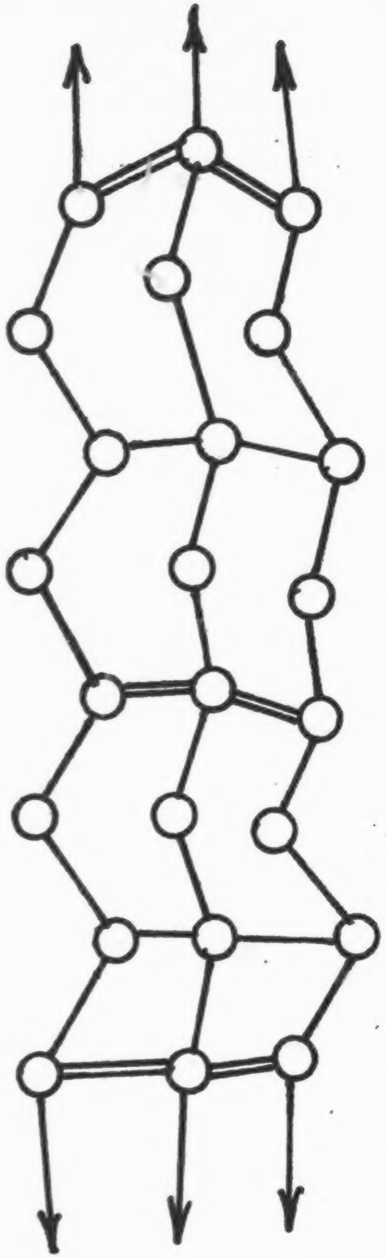
POLYMER DEFORMATION BY BOND STRAIGHTENING





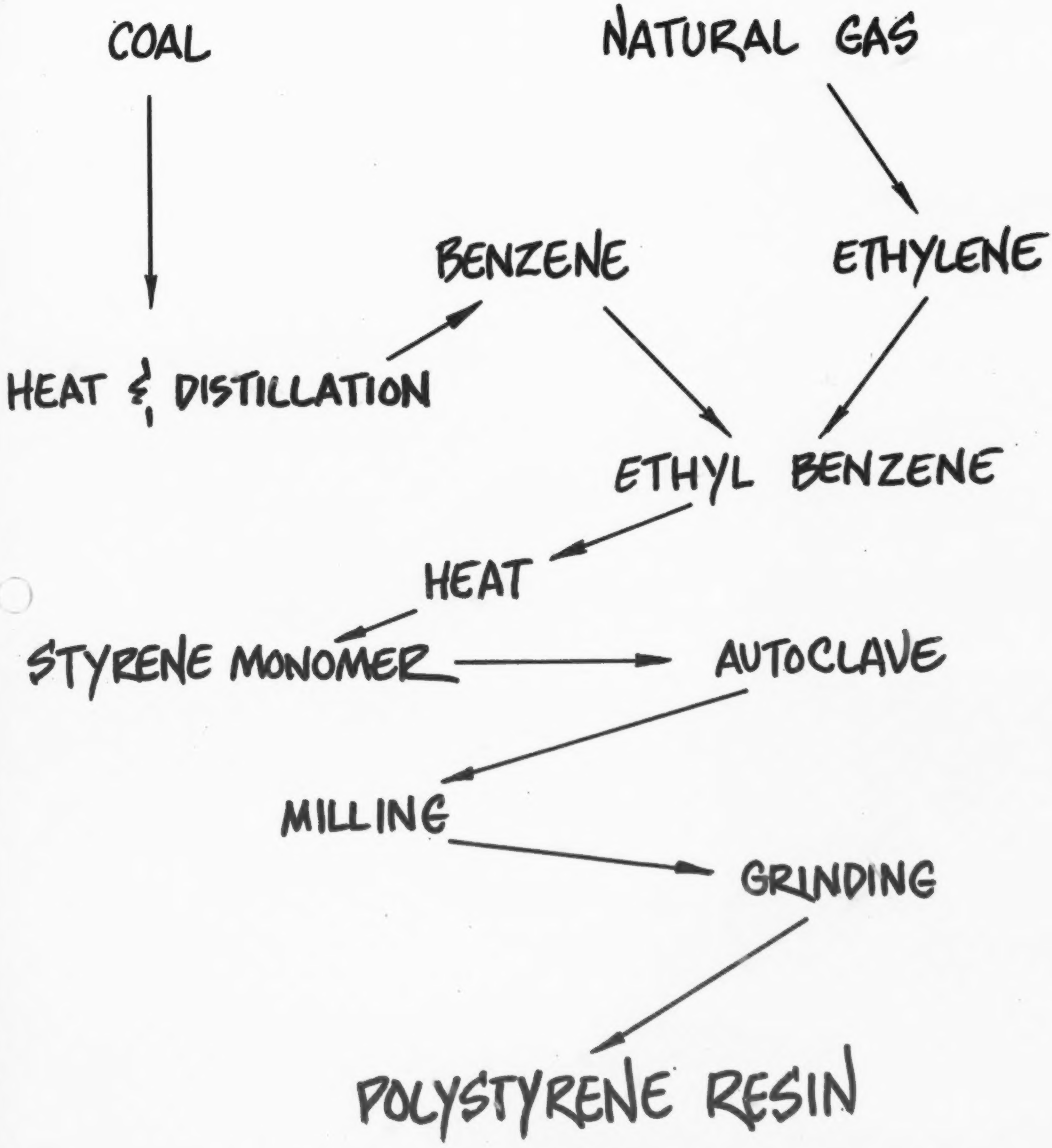
THERMOPLASTIC

Chain-like

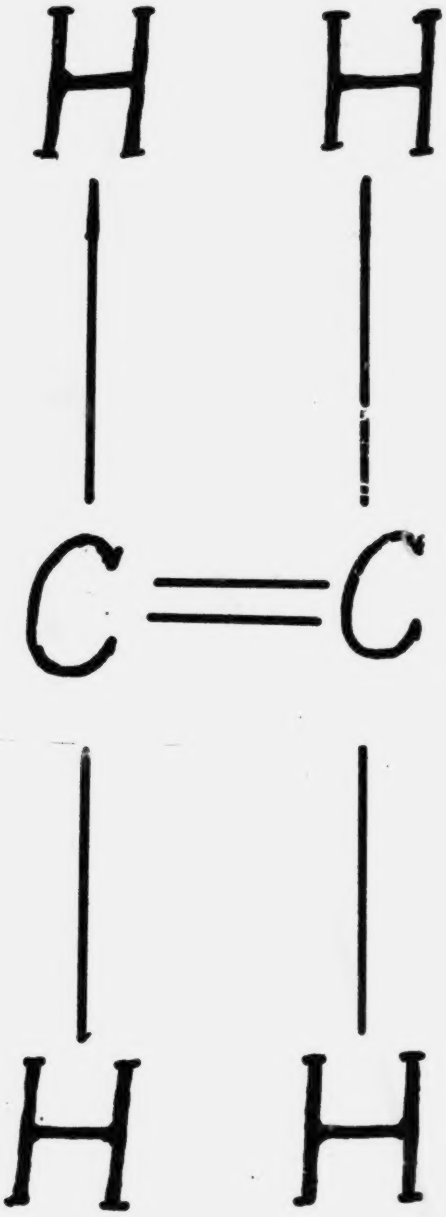


THERMOSET

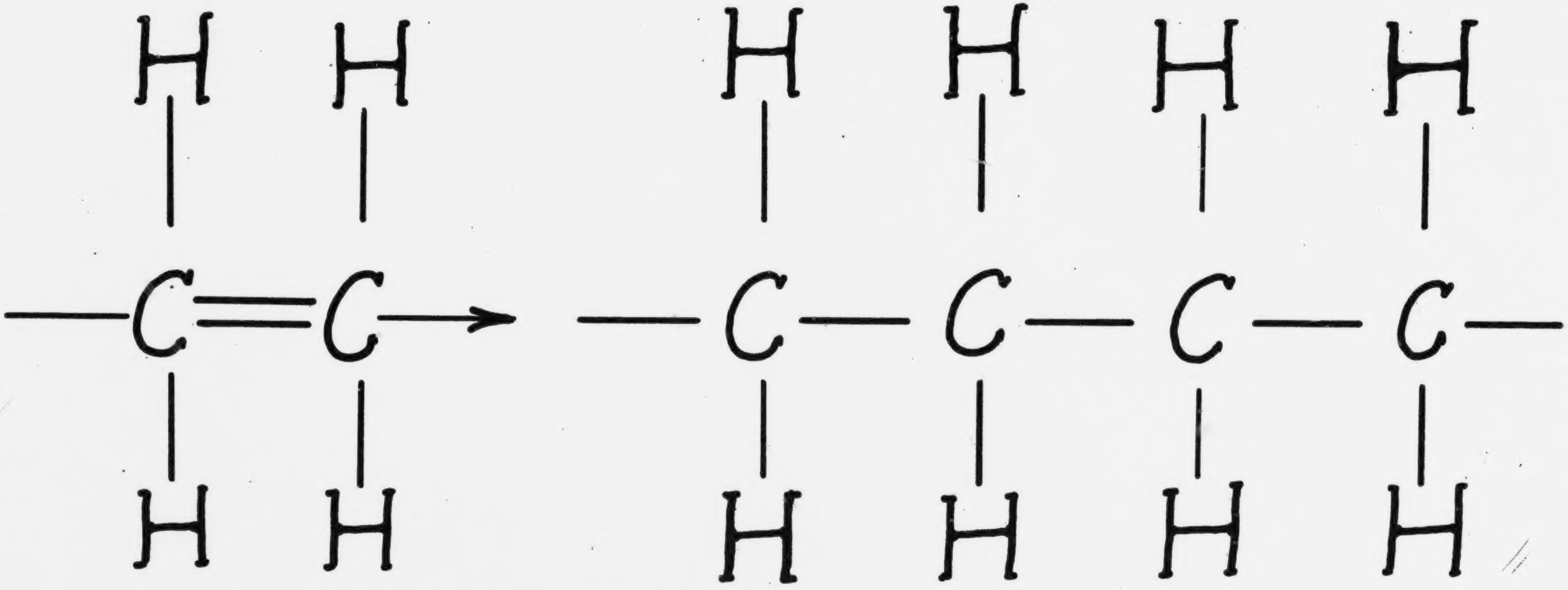
Cross-links


COAL
NATURAL GAS
BENZENE
ETHYLENE
HEAT & DISTILLATION
ETHYL BENZENE
HEAT
STYRENE MONOMER
AUTOCLAVE
MILLING
GRINDING
POLYSTYRENE RESIN

ETHYANE 7/48



Addition Polymerization



ELECTRONICS

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
[illegible] NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: Austin E. Lucero
Adrian Wilcox High School
Santa Clara, California

INSTRUCTIONAL LEVEL: 9 - 12 (Beginning Class Electricity

TITLE: The Effect of Temperature on Wire Molecular Activity

PRESENTATION TIME: 2 hours

INTRODUCTION:

This unit is designed to reinforce the principles of increase in molecular activities in metal when the temperature increases. This increase will be illustrated in the measurement of the heated conductor. The result should be significant if nichrome wire is used in the demonstration or experiments.

OBJECTIVES:

1. To demonstrate the importance of selecting correct size wire for the construction of an electronic unit.
2. To impress upon the minds of students the importance of using house circuits only to their safe limit. To avoid overloading.
3. To understand the metallic materials nichrome as a sample wire.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Electricity

INTER-RELATION WITH OTHER SUBJECTS:

The principle of molecular activity is discussed in chemistry classes, general science and sometimes in math classes when constants are the subject matter. Of course, the metals class can use this information to a slight degree.

USE IN INDUSTRY:

1. A major consideration in electrical industrial complexes is the dissipation of heat in chassis
2. Metal expansion in cables (consoles, bridges, and high voltage lines

MATERIALS AND EQUIPMENT:

1. Heat source - candle, kiln of any size, etc.
2. Wire samples - to include nichrome
3. Jig to suspend wire

4. Power supply (high current and low voltage; 10-20 amps, 20 volts)
5. Ammeter
6. Voltmeter
7. Ohmmeter

EDUCATIONAL MEDIA:

1. Use of overhead projector (trans. of activity table)
2. 3-D Teaching Aid
3. Expansion and Contraction Demonstrator
4. Lecture
5. Student Experiment

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT

SAFETY:

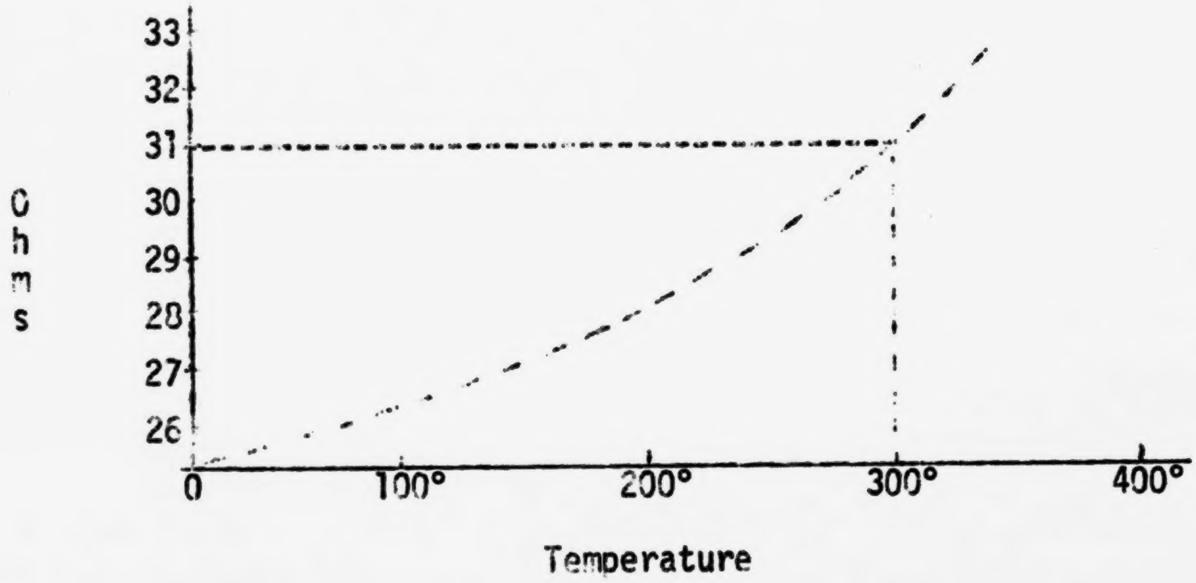
Safety in working with these materials is, of course, taught, but it is hoped that this safety training will go beyond the school room door.

PRESENTATION:

I. Experiment - Temperature changes and its effect on conductors.
   A. Parts and Equipment
      1. Nichrome wire (small gauge)
      2. Heat source (kiln, candle)
      3. Ohmmeter
   B. Set-up (see diagram 1 attached)
   C. Procedure
      1. Measure wire resistance while cold. Record ________
      2. Turn on kiln after the test wire is inserted through the door vent hole and drawn out through the pyrometer aperture.
      3. At given time intervals, measure the resistance and record in the table. And also record the temperature and time.

TIME	RESISTANCE	TEMPERATURE
0	26 ohm (per ft.)	Normal
5	26+ x	N + 20°
10	26+ x	N + 20°
15	26+ x	N + 20°

D. Graph of Experiment



E. Conclusion
There must be a high degree of electron activity with the increase of temperature around a given conductor. This conclusion is evident because of the increase in resistance.

F. Experiment Modification
If no kiln is available, merely obtain resistance wire and measure its ohmic value. Then while the ohmmeter is still connected, heat the wire uniformly with a candle, bunsen burner or another means -- the ohmic increase is immediately evident. This method is not accurate but it does prove a point.

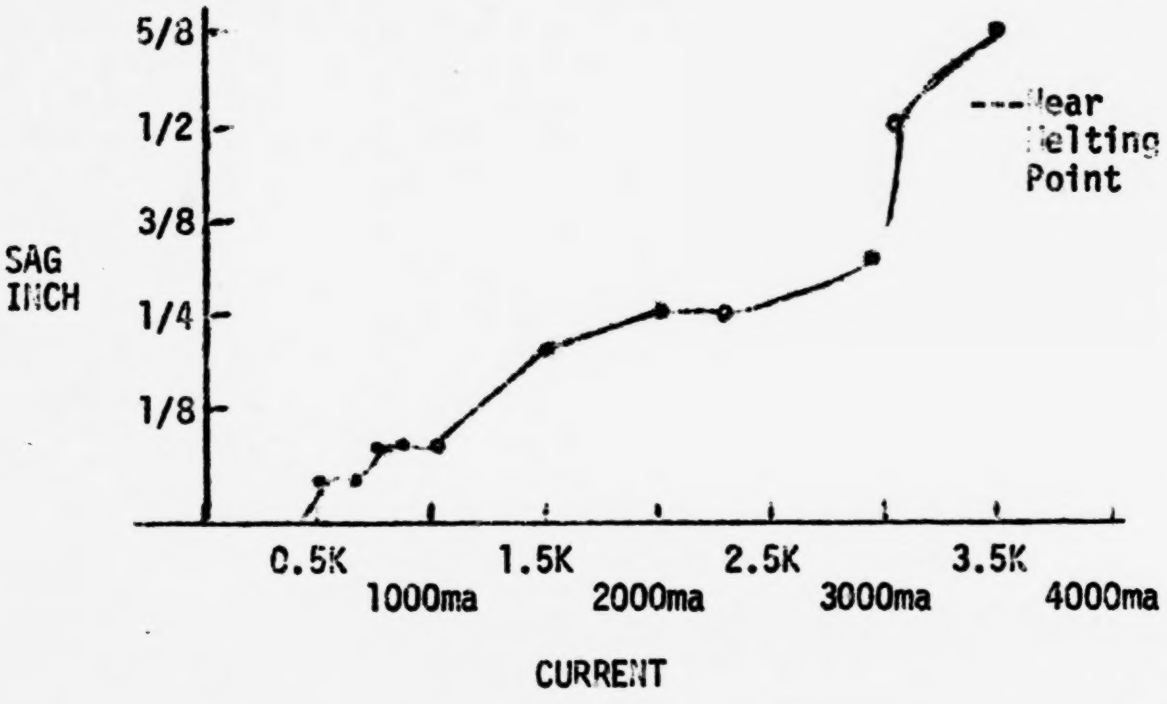
II. Experiment - Expansion of electrical wire when acting as a current carrier
A. Materials and Equipment
Nichrome wire, Ammeter, Volt meter
Power Supply Low Voltage High Current
Test Wire Holding Device, small weight
B. Procedure (see diagram 2 attached)

The measurements to be taken during this experiment will, when plotted on a graph, illustrate that high thermal agitation is created with current flow and an increase in current flow creates an increase in electron activity which when allowed or when unrestrained will expand its spacial requirement.

If the resistance wire is tightly stretched between the two insulators and its relative distance to the ground surface is measured, then any expansion or sag will be measured on the vertical scale. (If a small weight is attached to the wire the sag will be easier to determine.

The readings to be taken are: current, volt, and sag, which will be plotted on a graph.

E.	I.	Sag
0	0	0
2.2	120 ma	0
2.5	220 ma	0
2.3	300 ma	0
3.1	400 ma	0
3.6	500 ma	1/32
3.9	600 ma	1/32
4.3	700 ma	1/16
4.7	800 ma	1/16
5.5	1000 ma	1/16
5.7	1500 ma	3/16
7.3	2000 ma	1/4
7.8	2300 ma	1/4
8.5	3000 ma	5/16
9.8	3100 ma	1/2
11.6	3500 ma	5/8



C. Conclusion

An increase in current reacted with an increase in heat which in turn caused the wire to sag. The sag then could only be attributed to the increased molecule activity. If the wire expanded or sagged then it can only hold true that thermal agitation causes electrons to demand more space, which they get, and this is indicated by the expansion of a metal.

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE:

Oral Quiz
Observation of student lab work

UNIT EVALUATION:

Has the lesson generated any self designed activities? Have student suggest or list possible experiment and how they can be done.

DEFINITION OF TERMS:

1. Ohm - The opposition to electrical current flow
2. Volt - The pressure used to cause current to flow
3. Current - The actual flow of electrons
4. Thermal action - The agitation of electrons in a heated electrical conductor

REFERENCES:

STUDENT:

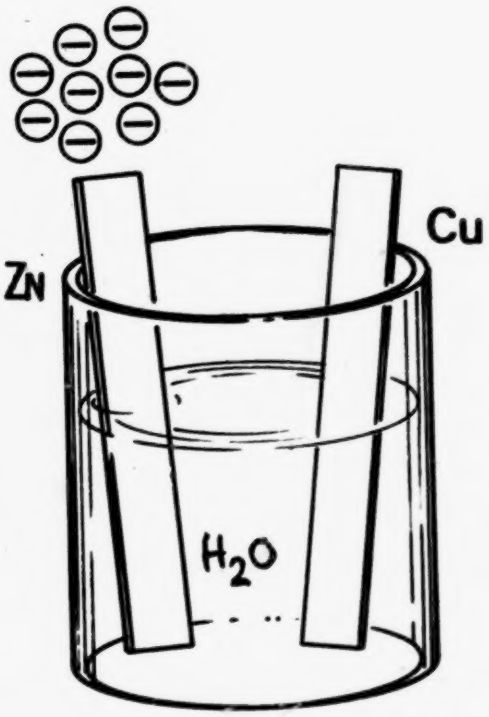
Electricity and Electronics for Everyone, Monroe Upton
Electricity, Howard Gerrish

ELECTRODE POTENTIAL OF METALS

METAL ION	POTENTIAL
Li^{+} (BASE)	+2.96 (ANODIC)
K^{+}	+2.92
Ca^{2+}	+2.90
Na^{+}	+2.71
Mg^{2+}	+2.40
Al^{3+}	+1.70
Zn^{2+}	+0.76
Cr^{2+}	+0.56
Fe^{2+}	+0.44
Ni^{2+}	+0.23
Sn^{2+}	+0.14
Pb^{2+}	+0.12
Fe^{3+}	+0.045
H^{+}	0.000 (REF)
Cu^{2+}	-0.34
Cu^{+}	-0.47
Ag^{+}	-0.80
Pt^{4+}	-0.86
Au^{+} (NOBLE)	-1.50 (CATHODIC)

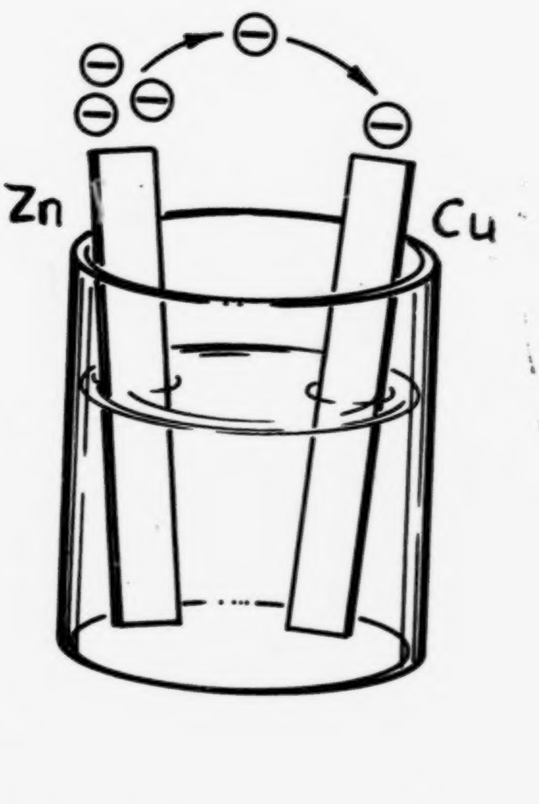
AN ACTIVE METAL WILL DESTROY ITSELF BY GIVING UP ELECTRONS TO A LESS ACTIVE METAL. THE ACTIVE OR DONOR METAL IS CALLED THE ANODE - THE ACCEPTOR IS CALLED THE CATHODE.

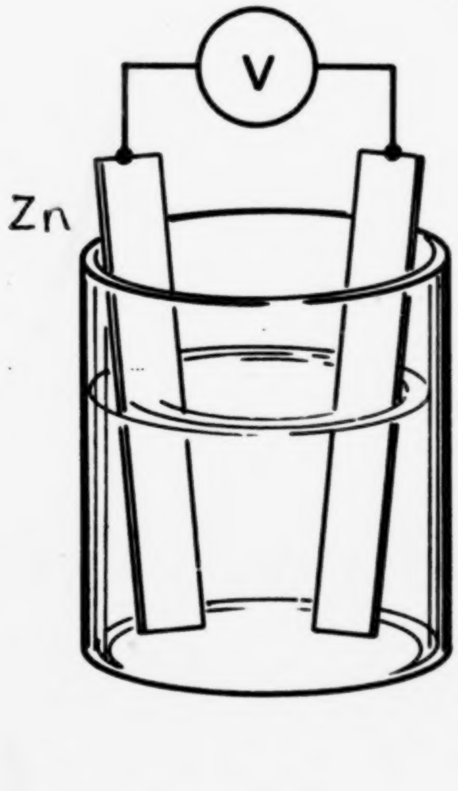
METALS THAT ARE CHEMICALLY ACTIVE WILL, WHEN CONNECTED TO LESS ACTIVE METALS, DESTROY THEMSELVES ATTEMPTING TO BALANCE AN UNBALANCED CONDITION.



ABUNDANCE OF ELECTRONS CREATES UNBALANCE

ELECTRONS KICKED OFF TO BALANCE CONDITION

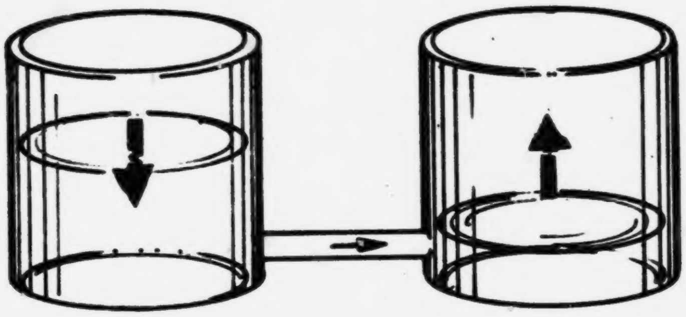




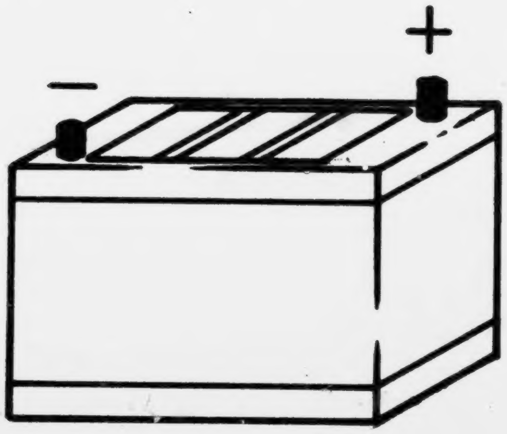
THIS ACTION IS MEASURABLE

NATURAL FORCES BALANCE UNBALANCED CONDITIONS

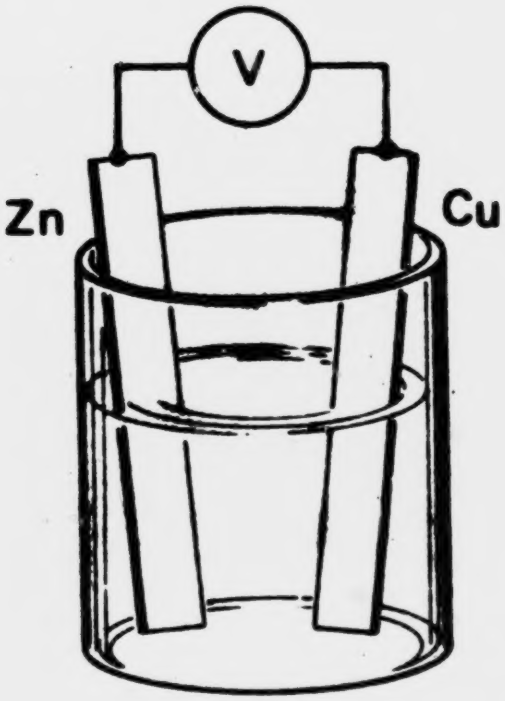
WATER LEVELS EQUALIZE DUE TO GRAVITY



A DEAD BATTERY IS A BALANCED BATTERY



ZINC ELECTRONS MOVE TO COPPER TO BALANCE THE ACTIVE METAL



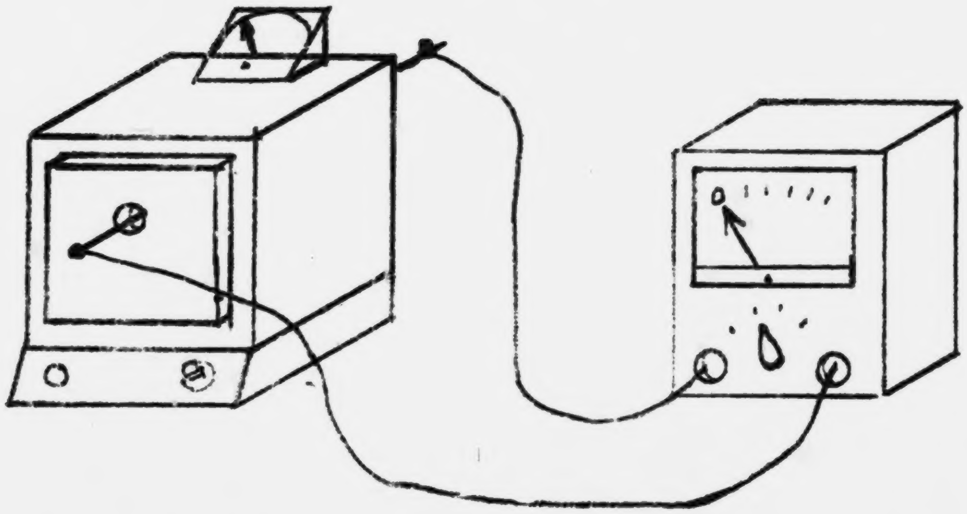


DIAGRAM 1

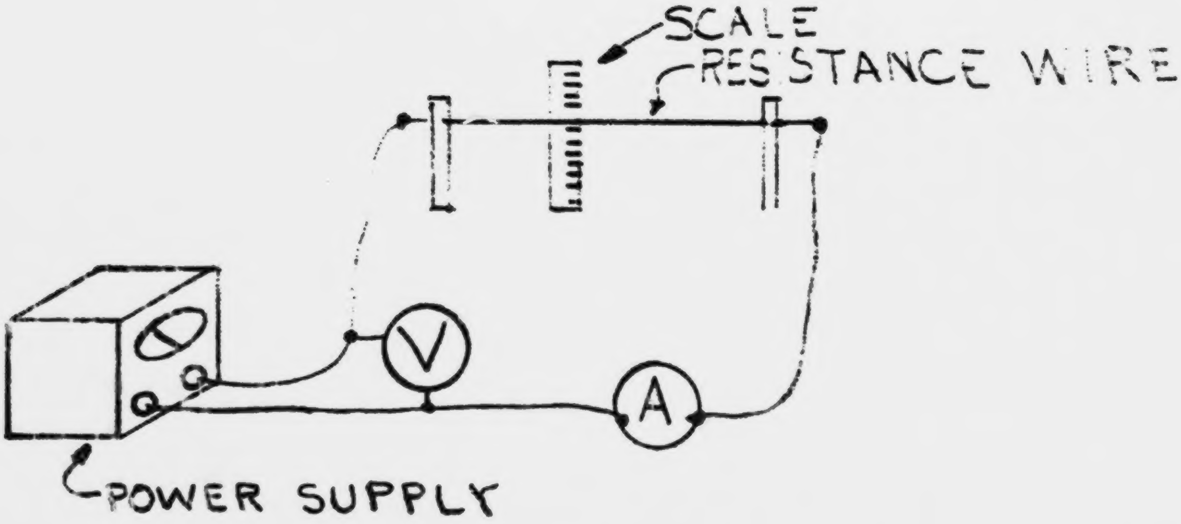

SCALE
RESISTANCE WIRE
V
A
POWER SUPPLY

DIAGRAM 2

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: Austin E. Lucero
Adrian Wilcox High SChool
Santa Clara, California

INSTRUCTIONAL LEVEL: High School

TITLE: Relative Activity of Metals and its effect on the Electrical Potential

PRESENTATION:TIME: 2 hours

INTRODUCTION:

Probably one of the first subjects covered in the area of electricity is the subject of atomic theory, and secondly the creation of electricity through the use of electrolyte, and dissimilar metals or materials. In short the subject is the battery and its capabilities. Therefore, this unit would help to reinforce that material which has previously been covered as well as introducing new materials.

OBJECTIVES:

1. To reinforce battery theory previously taught
2. To demonstrate that one metal will give up its electrons to a less active metal if there is an electrolyte and contact of some source.
3. To demonstrate that a potential is generated between metals or that an unbalanced condition in nature becomes balanced through physical forces.
4. To depict the effect of magnetism on metals of different activity ratings.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Electricity/Electronics

INTER-RELATION WITH OTHER SUBJECTS:

In chemistry classes the periodic chart is one of the primary items discussed, however, when one says that a given metal is active very frequently the only proof given is the demonstration which requires that pure sodium be placed in water. The physics class also use batteries and since batteries are metal utilizing bodies it is felt that this unit can be of help in this area.

USE IN INDUSTRY:

Sacrificial metal processes are a common application in industry - consider the outboard motor which is protected against corrosion by a small piece of active metal which is attached to the submerged portion of the motor.

MATERIALS AND EQUIPMENT:

voltmenter
ammeter
NaCl (sodium chloride) table salt
variety of metals
H_2O (water, not distilled)
different types of wire

EDUCATIONAL MEDIA:

transparencies - attached
demonstration
metals activity chart

UTILIZATION IN THE TEACHING LEARNING ENVIRONMENT:

SAFETY:

No hazard unless caustic solution substituted for electrolyte.

PRESENTATION:

1. Give a short introduction about metal valence and electron number, use transparency #1.
2. Perform experiment to class by following attached
3. Conclusion as apropriate
4. 4. Transparencies - 2, 3, 4.

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE:

1 paragraph written explanation of what students have seen

UNIT EVALUATION:

Have students design the most powerful potential difference after having been given several different metals. Once designed, have the student test the theory.

DEFINITION OF TERMS:

Sacrificial Metals - a metal that destroys itself when it is coupled to or made to come in contact with another metal.

Magnetic Induction - the process by which electricity is created in a conductor when that conductor is passed through a magnetic field.

REFERENCES:

STUDENT:

Suban & Schmidt - ELECTIICITY

TEACHER:

Van Vlack - ELEMENTS OF MATERIALS SCIENCE
Keyser - MATERIALS SCIENCE IN ENGINEERING

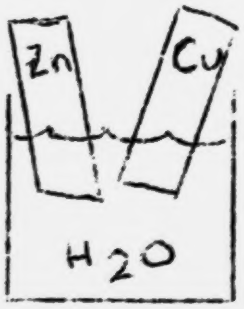
EXPERIMENT: ELECTRICAL POTENTIAL AND CONDUCTIVITY OF DIFFERENT METALS.

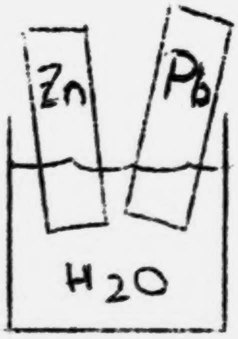
MATERIALS & EQUIPMENT:

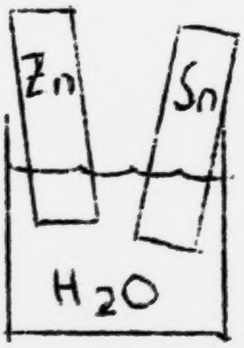
1. Strips of a variety of metals - same size
2. Voltmeter
3. Ammeter
4. Resistor - 100 ohms
5. Tap water - salt water (tap water & NaCl)
6. Several glass beakers

PROCEDURE:

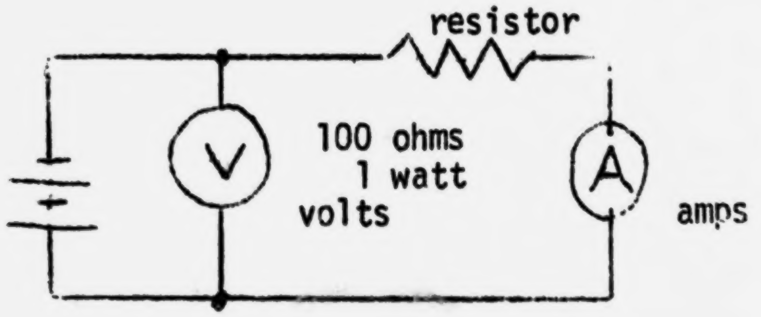
Select the most active metal of the cut strips, zinc in this case, and use that metal as a reference point. Place that metal in each beaker and make the second metal different - as illustrated:







This particular experiment utilized zinc, copper, and tin. The results of each experiment were tabulated as indicated in the chart below. The electrical circuit uses the standard battery symbol to depict the dissimilar metals in the electrolyte.



ELECTROLYTE	MATERIALS	NO LOAD		FULL LOAD		DOUBLE METAL SURFACE	
		VOLTAGE	CURRENT	VOLTAGE	CURRENT	VOLTS	CURRENT
TAP WATER	COPPER ZINC	1	0	.25	.2	.25	3ma
	ZINC ZINC	0	0	0	0		
	ZINC TIN	.7	0	.7	near zero		

CONCLUSION:

The wider the range between the selected metals on the activity metals chart the higher the voltage reading. If a metals surface area is increased, the voltage remains the same and the current increases. Two similar metals will not create any voltage.

EXPERIMENT: HOW TO DEMONSTRATE ACTIVITY OF METALS

MATERIALS & EQUIPMENT:

1. Sodium metal
2. Beaker
3. Tap water
4. Phenolph Thalein

PROCEDURE:

1. Fill beaker about half full with water
2. Carefully remove piece of sodium metal (the size of a pea) from its special container. DO NOT touch the metal to the unprotected skin - the metal will react with your body moisture.
3. Place the sodium in the beaker of water and observe the reaction
4. In order to illustrate to the students what has taken place in the beaker drop some phenolph thalein in the beaker and again observe the reaction. (or use litmus paper). The water will turn blue if the solution is base, red if it is acid.

CONCLUSION:

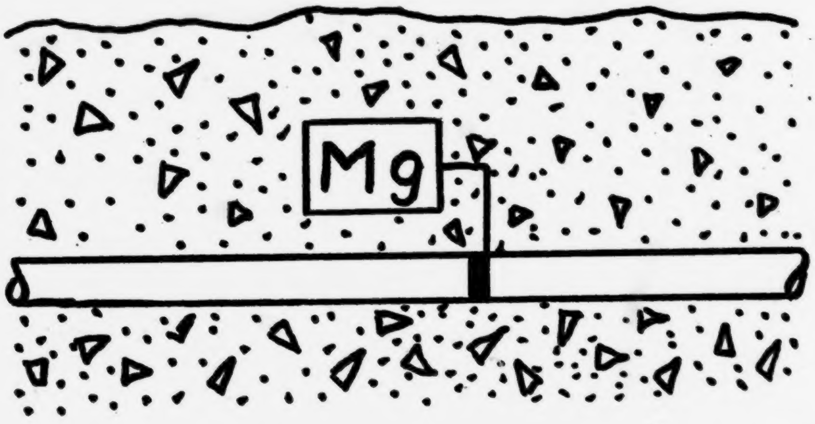
The sodium is so active that is destroys itself and this can be observed in two ways: the metal disappears, the water loses its semineutral state.

ELECTRODE POTENTIAL OF METALS

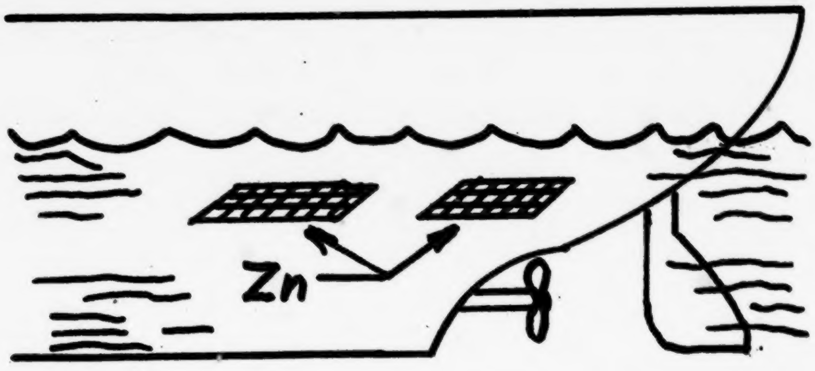
METAL ION	POTENTIAL
Li^+ (BASE)	+2.96 (ANODIC)
K^+	+2.92
Ca^{2+}	+2.90
Na^+	+2.71
Mg^{2+}	+2.40
Al^{3+}	+1.70
Zn^{2+}	+0.76
Cr^{2+}	+0.56
Fe^{2+}	+0.44
Ni^{2+}	+0.23
Sn^{2+}	+0.14
Pb^{2+}	+0.12
Fe^{3+}	+0.045
H^+	0.000 (REF)
Cu^{2+}	-0.34
Cu^+	-0.47
Ag^+	-0.80
Pt^{4+}	-0.86
Au^+ (NOBLE)	-1.50 (CATHODIC)

AN ACTIVE METAL WILL DESTROY ITSELF BY GIVING UP ELECTRONS TO A LESS ACTIVE METAL. THE ACTIVE OR DONOR METAL IS CALLED THE ANODE - THE ACCEPTOR IS CALLED THE CATHODE.

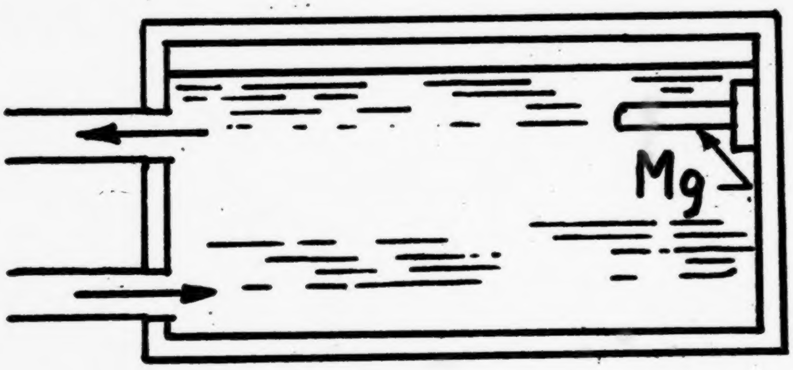
Sacrificial Anodes



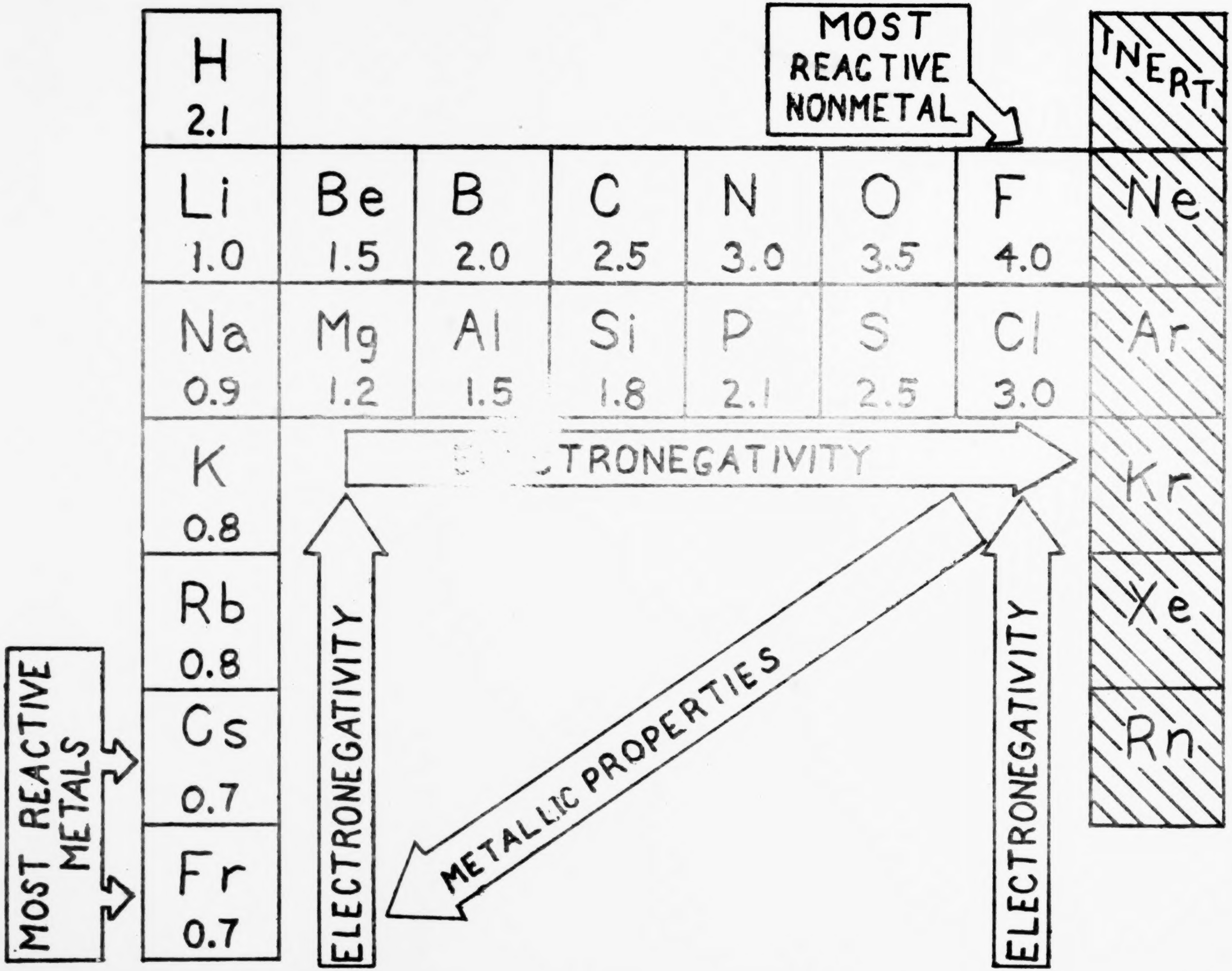
Buried Mg plates along a pipeline



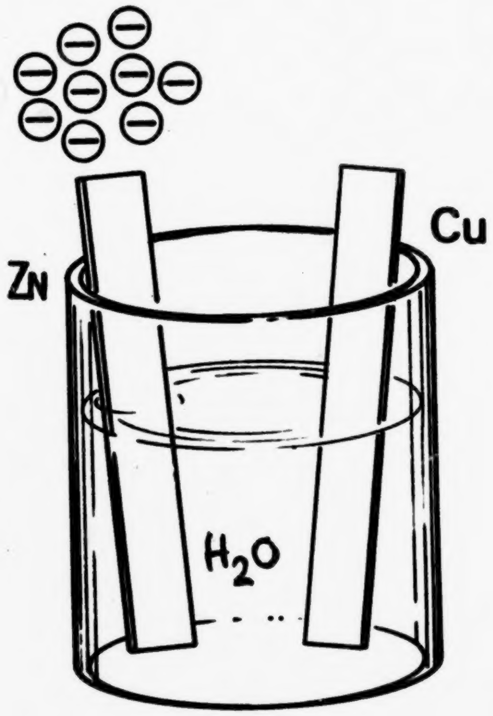
Zinc plates on ship hulls



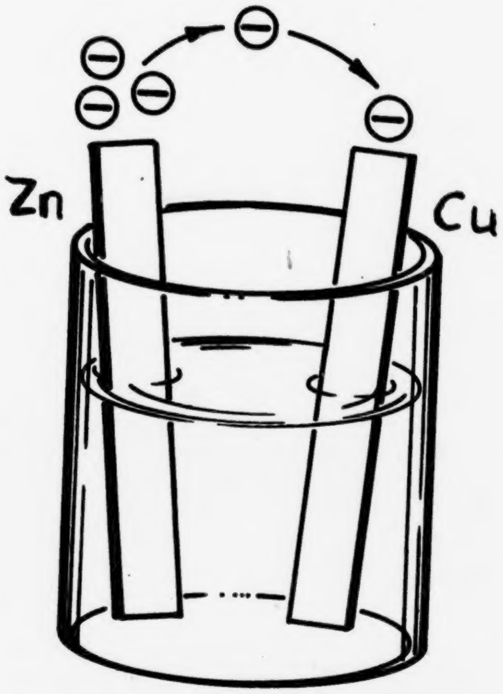
Mg bar in an industrial hot water tank


MOST REACTIVE NONMETAL
INERT
H 2.1
Li 1.0
Be 1.5
B 2.0
C 2.5
N 3.0
O 3.5
F 4.0
Ne
Na 0.9
Mg 1.2
Al 1.5
Si 1.8
P 2.1
S 2.5
Cl 3.0
Ar
K 0.8
Kr
Rb 0.8
Xe
Cs 0.7
Rn
Fr 0.7
ELECTRONEGATIVITY
ELECTRONEGATIVITY
METALLIC PROPERTIES
ELECTRONEGATIVITY
MOST REACTIVE METALS

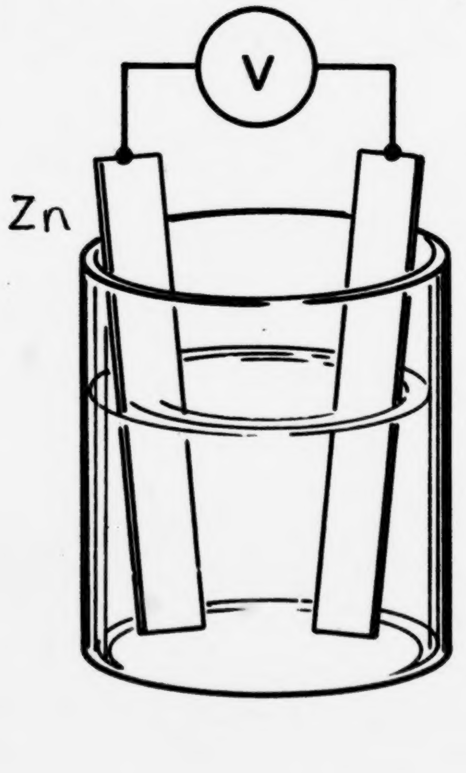
METALS THAT ARE CHEMICALLY ACTIVE WILL, WHEN CONNECTED TO LESS ACTIVE METALS, DESTROY THEMSELVES ATTEMPTING TO BALANCE AN UNBALANCED CONDITION.



ABUNDANCE OF ELECTRONS CREATES UNBALANCE



ELECTRONS KICKED OFF TO BALANCE CONDITION



THIS ACTION IS MEASURABLE

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: Austin E. Lucero
Adrian Wilcox High School
Santa Clara, California

INSTRUCTIONAL LEVEL: High School

TITLE: Semi-Conductor Materials and Doping Processes

PRESENTATION TIME: 2 hours

INTRODUCTION:

Probably in no other area of electronics does the subject of materials fit more appropriately than in the area of solid state electronics. Therefore, this unit is designed to deal only with semi-conductor materials.

OBJECTIVES:

1. To illustrate how electronics uses materials which are neither conductors or insulators in a controlled environment to produce electrical work of many parts.
2. To illustrate how a semi-conductor material with a valence bond of four can be made to act as a positive of negative material.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Electronics (Semi-Conductors)

INTER-RELATION WITH OTHER SUBJECTS:

1. This area of study could be related to chemistry, physics and the co-valent bonding could be related to some metals materials.
2. Electricity classes.

USE IN INDUSTRY:

1. Semi-conductors are so widely used in industry that complete factories have been built for the sole purpose of making semi-conductors.

2. Used in any form of communication, warfare, test instrumentation.

MATERIALS AND EQUIPMENT:

Meters (V.T.V.M.) Vacuum tube voltmeter
Diodes germanium

Diodes silicon
Transistors - any type. P.N.P. is best to use

EDUCATIONAL MEDIA:
Transparencies as shown on attached sheets.

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT:

SAFETY - No real hazard involved.

PRESENTATION:

PART I.

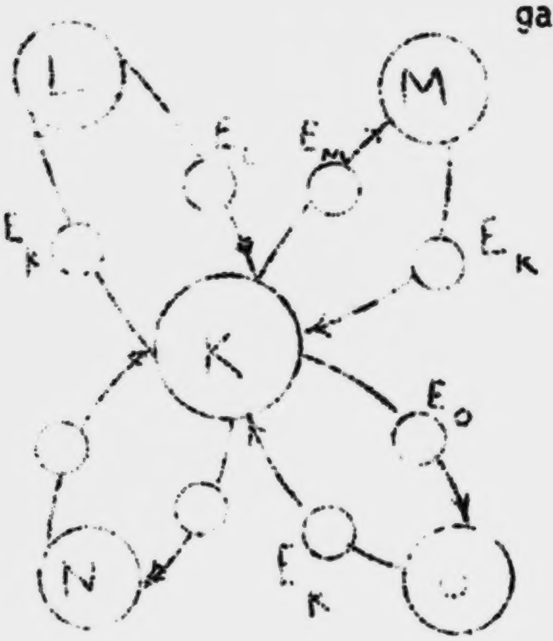
I. Insulators and conductors
   A. The number of electrons on the atom's outer ring determines the conduction of the element. Metals, for example, are good conductors and metals as a whole generally have 1, 2, or 3 electrons on the outer atomic ring. Valence is the technical name for the 1, 2, or 3 electrons.
      1. The 1, 2, or 3 electrons may be released from their orbit with relative ease; hence, they are good conductors.
      2. Non-conductors or insulators--there are no perfect insulators because of the constant introduction of impurities. However, insulators do not have very easily removed electrons from the outer orbit.
   B. Semi-Conductors
      1. A group of materials which will conduct electrons poorly, thus cannot be classified as either a conductor or non-conductor. Germanium and silicon are such materials.
      2. However, impurities may be added to semi-conductor materials with two possible results--an excess of electrons in the impure material or a deficiency of electrons and this depends on which material is added as the impurity.
      3. Doping - the process of adding an impurity to a pure semi-conductor material such as germanium.
      4. When an impurity with five electrons in its valence bond is added to a semi-conductor material, that newly doped material is negative in nature and is thus called an "N-type"material. If, however, the impurity which is added to the semi-conductor is tri-valent, then the newly formed material is positive in nature and it is thereby called P-type material.

a. Typical impurities
Arsenic = Pentavalent (5-electrons)
Indium = Trivalent (3-electrons)

5. The natural tendency for 8 electron orbital rings to be formed is the base for semi-conductors (4 electron orbits) to form groups and share electrons; hence, one atom of a semi-conductor shares four electrons with four adjacent atoms.

Co-valent Bonding

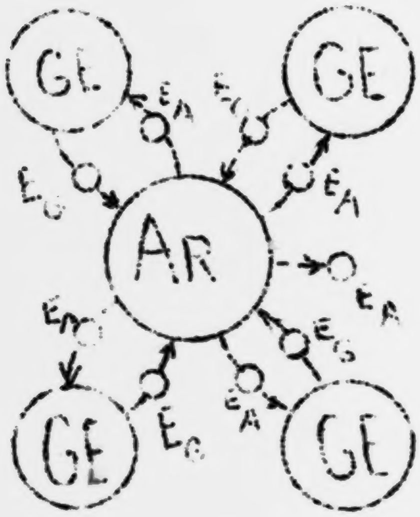
All atoms are Germanium. Note that 8 electrons are gathered around atom K.



II. N-Type Materials

A. When a material such as arsenic with a valence of 5 (5-electrons) is confined with germanium, the the arsenic impurity creates a problem--too many electrons

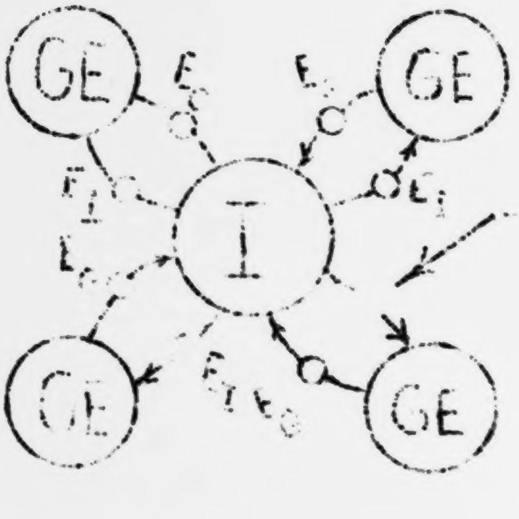
PentaValent


GE
GE
AR
GE
GE
E_A
E_G

Germanium and Arsenic Combination. Arsenic is a donor because it provides free electrons
5-4=1
Hence--N-type crystal

III. P-Type Material

Germanium and Indium.


GE
GE
I
GE
GE
E_G
E_I

No electron. Indium has only a valence of 3. Hence a hole is created.

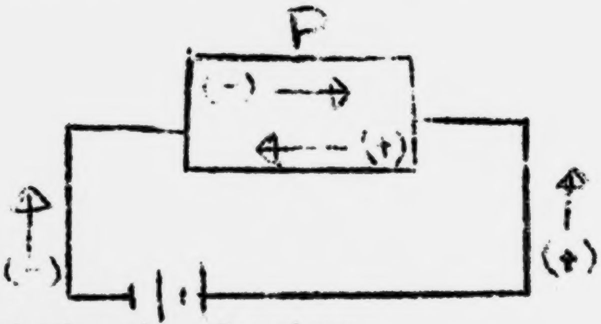
Acceptor because it accepts one more electron

PART II.

P-N Junction Action

I. Molecular Action
   - A. Heat must be present in order to sustain electron motion.
     1. As the heat increases, electrons begin to move from one orbital ring to another.
     2. With each move a Hole is left--hence, one has what is known as electron hole pairs.
   - B. The motion is random in nature with the exception of the application of an electrical potential.
     1. A battery sets up such a field and if it were possible, one would see the holes gravitating toward the negative terminal of the battery. Thus, doped semi-conductor materials are made to maintain a controlled electron flow.
     2. The electric field is carrier.
     3. Electrons will gravitate toward (+) the positive side of the field.
     4. Note the hole and electron flow are in opposite directions, as in the diagram.

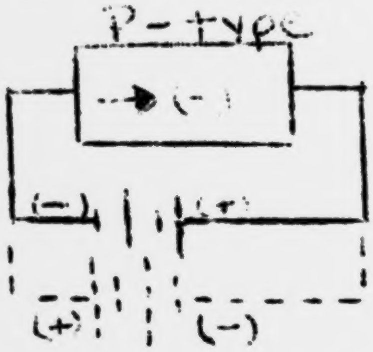
Fig. 1



II. Majority and Minority Carriers
   - A. Semi-conductor plus doping impurities with extra electrons is called an N-type crystal with electrons as majority carriers.
     1. P-type crystals have a deficiency of electrons because of trivalent impurities which establishes an excess of holes.
     2. Donor Atoms - (Impurities with extra electrons)
        Acceptor Atom - (Deficient electrons which leave holes)

III. Batteries and "N" and "P" type crystals.
   - A.

Fig. 2



Note: electron flow can be reversed in a P-type crystal by merely reversing the polarity. In a P-type crystal, the hole (+) is the majority carrier.

B. When the crystal is of the "N-Type", the battery polarity may be reversed; however, one should remember that the electron is the majority carrier.

IV. P-N Junction

How does a P-N Junction work? What action takes place in the P-N junction?

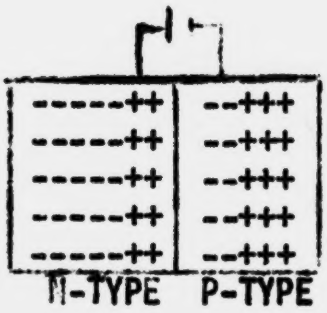


Fig. 3

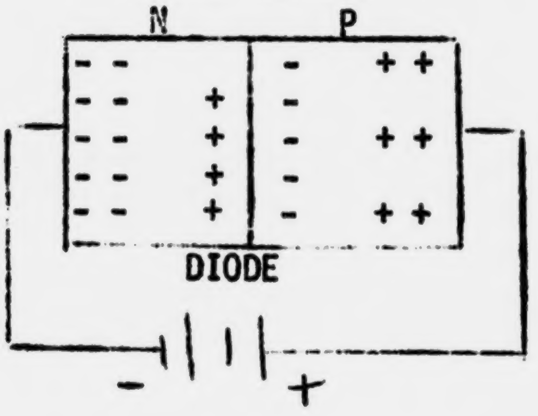
A. The region in which both semiconductors are joined is called a junction. It should be noted that a junction is not a surface separating one material from another; it is a region in which both materials are atomically dissolved into one another.

B. A charge is actually developed at the junction which has a repelling action on the flow of anything.
   1. The electrons in the N-type material cannot immediately flow to the P-type side because of the already negative barrier on the P-type side of the junction and visa versa for the hole flow. (See figure 3 for barrier formation)

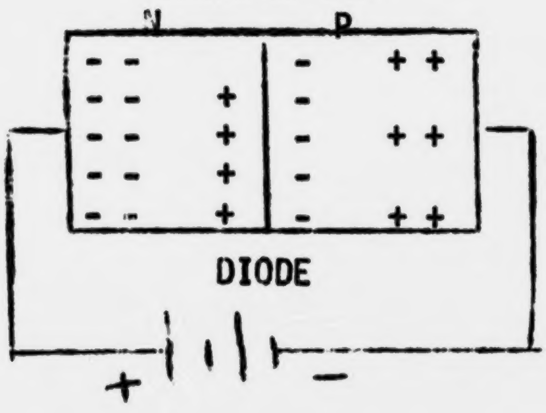
V. Forward and Reverse Biasing

A. If the internal field created by the charged atoms along the junction is reduced by suitable means, the flow of holes from P-type into N-type material, and electrons from the N-type into P-type materials will be promoted. A correctly connected battery will accomplish this.

FORWARD BIAS



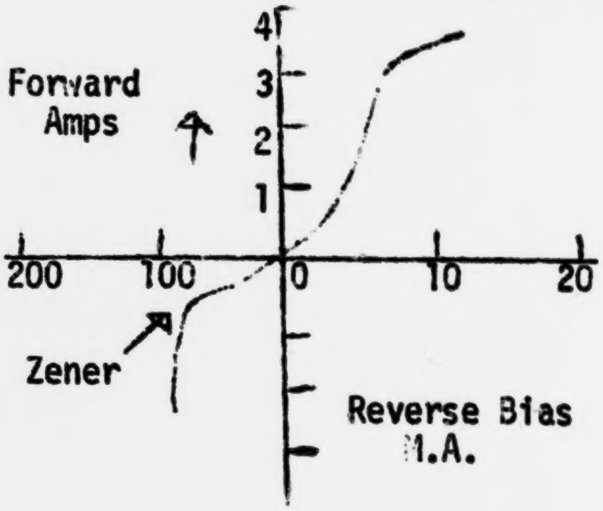
REVERSE BIAS



B. The battery in Forward Bias opposes the internal charge and increases electron flow. The (-) units are pulled through P-type material to the positive side of the battery.

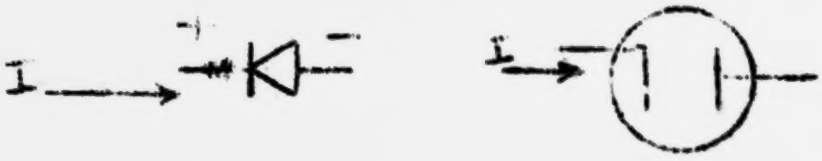
C. Rules for forward and reverse bias
   1. If the design is to obtain flow of current through a junction, the power source should be connected for forward bias which is with the positive power source terminal connected to the P-side and the negative connected to the N-side of the diode.
   2. However, if the design is to reduce current flow through the diode, the degrees of reversing will eventually drive the diode to complete cut-off. The power source terminals must be connected...Positive terminal to N-side of the diode.

D. Biasing effect on current flow



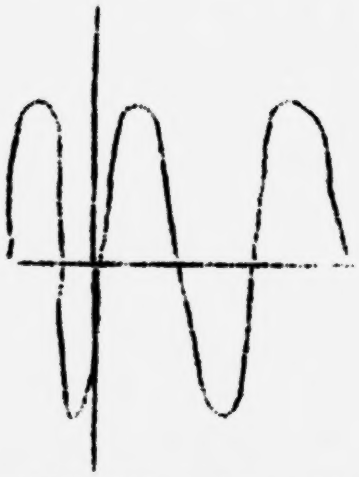
   1. Note: the portion to the right of zero current line indicates a current increase with increase in voltage with forward bias.
   2. The section to the left of zero depicts a steady current decrease with reverse bias. Note also that forward bias produces amperes and reverse is milliamperes.

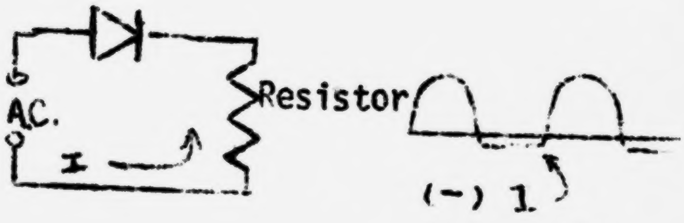
Diode Symbols and Current Flow



   3. Two types of current flow
      Drift = caused by battery
      Diffusion = natural electron and hole attraction

E. Rectification Properties of a diode
   1. If an A.C. source is connected across the junction, the resulting carrier flow is high for 1/2 cycle and low for the other half.
      Thus PN or NP junction can act as a rectifier.





Note small amount of negative current

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE

1. Student will select and connect diodes in low voltage A.C. circuits and observe the pattern on the scope.
2. Check current flow direction with series connect ammeters.

UNIT EVALUATION:

1. Written quiz on each division.
2. Simple power supply design

DEFINITION OF TERMS:

1. Semi-conductor - any material located in valence 4 bond of periodic chart.
2. Co-valent bond - to share electrons
3. Forward bias - + side of battery connected to + side of diode.
4. Reverse bias - (-) side of battery connected to N side of diode.
5. Zener - the reverse current flow breakdown point

REFERENCES:

Semi-conductor Fundamentals by Seidman

GRAPHIC ARTS

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: John Gedker
Fairmont State College
Fairmont, West Virginia

INSTRUCTIONAL LEVEL: College

TITLE: Chemistry of Printing Inks

PRESENTATION TIME: 1 period

INTRODUCTION:

The field of printing inks is a vast complicated subject involving huge sums of money in research and development every year. The major emphasis of research is in the field of chemical blending to obtain the desired ink characteristics.

This unit, therefore, will introduce the chemistry involved in the basic materials and processes in making inks.

OBJECTIVES:

1. Enable students to observe and make samples of ink.
2. Enable students to understand the usage of various materials in making ink.
3. Enable students to understand the molecular movements and actions that create phenomenon such as tack and length of ink.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Graphic Arts Printing

INTER-RELATION WITH OTHER SUBJECTS:

Science: Molecular structures and movements of materials involved in making inks.

Social science: The complexities of industrial technologies are reflected in social science.

Physics: Principles of physics are involved in discussing the physical characteristics and actions of ink.

USE IN INDUSTRY:

The ink industry is a multimillion dollar industry and is increasing with the demands of new materials requiring printed surfaces.

MATERIALS AND EQUIPMENT:

Materials: 1. Basic components of ink including various pigments, vehicles, driers, and modifying agents.

2. Various types of inks to show comparisons of physical properties.

Equipment: The equipment can be sophisticated and include a viscometer, pigment grinder, etc., but with a few test tubes, ink plate, spatulas, morter and pestel, and a blending device such as steel balls in a steel container and an agitator such as a paint mixer, the subject can be adequately covered.

EDUCATIONAL MEDIA:

5 transparencies
4 demonstrations
1 chart

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT:

SAFETY:

1. Certain materials used in making ink have a low flash point and may cause adverse reactions on contact with a person's skin.
2. Machinery used in blending ink mixtures may be unguarded and safety precautions must be made concerning rollers gears, etc.

PRESENTATION:

I. Basic Materials Tr. 1
    A. Pigment
        1. Inorganic
            a. Carbon Black
            b. White
            c. Colored
        2. Organic
            a. Molecular Arrangement
            b. Classes
    B. Vehicle
        1. Drying oil
        2. Resin solvents
        3. Alkyd varnishes
        4. Gloss varnishes
        5. Plastic base

- C. Driers
  - 1. Composition
  - 2. Catalystic action
  - 3. Crystallization
  - 4. Usage
- D. Modifiers
  - 1. Anti skinning
  - 2. Wax
  - 3. Reducers
  - 4. Solvents
- E. Extenders

II. Manufacture(Overview of Procedures) Tr. 2
- A. Selection of materials
- B. Mixing Dem. 1
- C. Grinding
- D. Testing

III. Physical Properties of Ink
- A. Viscosity Tr. 3
  - 1. Numbering system
  - 2. Molecular forces Dem. 2
  - 3. Measurement
- B. Tack Tr. 4
  - 1. Molecular conditions
  - 2. Ink film separations Dem. 3
  - 3. Measurements
- C. Length Tr. 5
  - 1. Molecular conditions
  - 2. Relation of tack to length Dem. 4
  - 3. Measurement
- D. Interrelations of physical properties
  - 1. Body
  - 2. Consistency

IV. Specialty Inks (overview) Chart 1
- A. Job
- B. Bond
- C. Halftone
- D. Cylinder
- E. News
- F. Lithographic
- G. Specialty inks

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE:
1. Evaluation of student experiments in making inks.
2. Examination to determine the retention of knowledge concerning chemical and physical properties of ink-making materials.

UNIT EVALUATION:

An evaluation based on final tests can determine the subject matter best retained and areas of greatest weakness among students. The unit can then be changed to better cover areas of weakness.

DEFINITION OF TERMS:

1. Viscosity - Resistance from internal molecular structures of a liquid to flow.
2. Tack - A measure of "stickiness"
3. Length - An ink may be long or short depending on how long a string of ink can be formed by drawing a finger up from the ink surface.
4. Opacity - The hiding or covering qualities of an ink.
5. Transparency - Does not have great hiding power.
6. Body - All around evaluation of an ink including tack, length, and viscosity.

REFERENCES:

STUDENT:

1. Polk, Ralph, The Practice of Printing, 1964.
2. Cogoli, John, Offset Fundamentals, 1968.
3. Karch, Randolph, Printing and the Allied Trades, 1962.

TEACHER:

1. Lithographic Technical Foundation, Chemistry of Lithography, 1961.
2. ASTM Manual on Coatings, Part 21, 1967 ed.

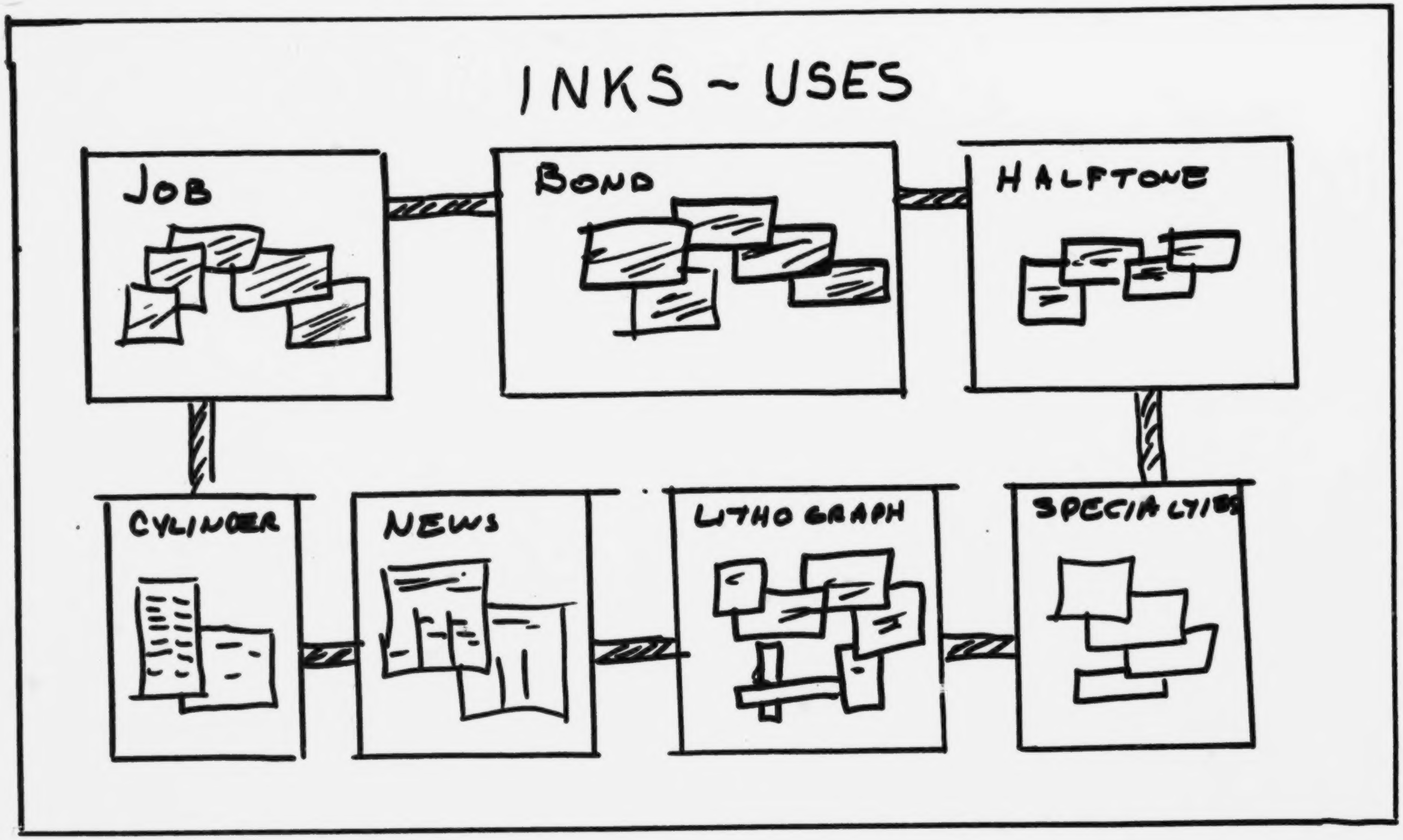
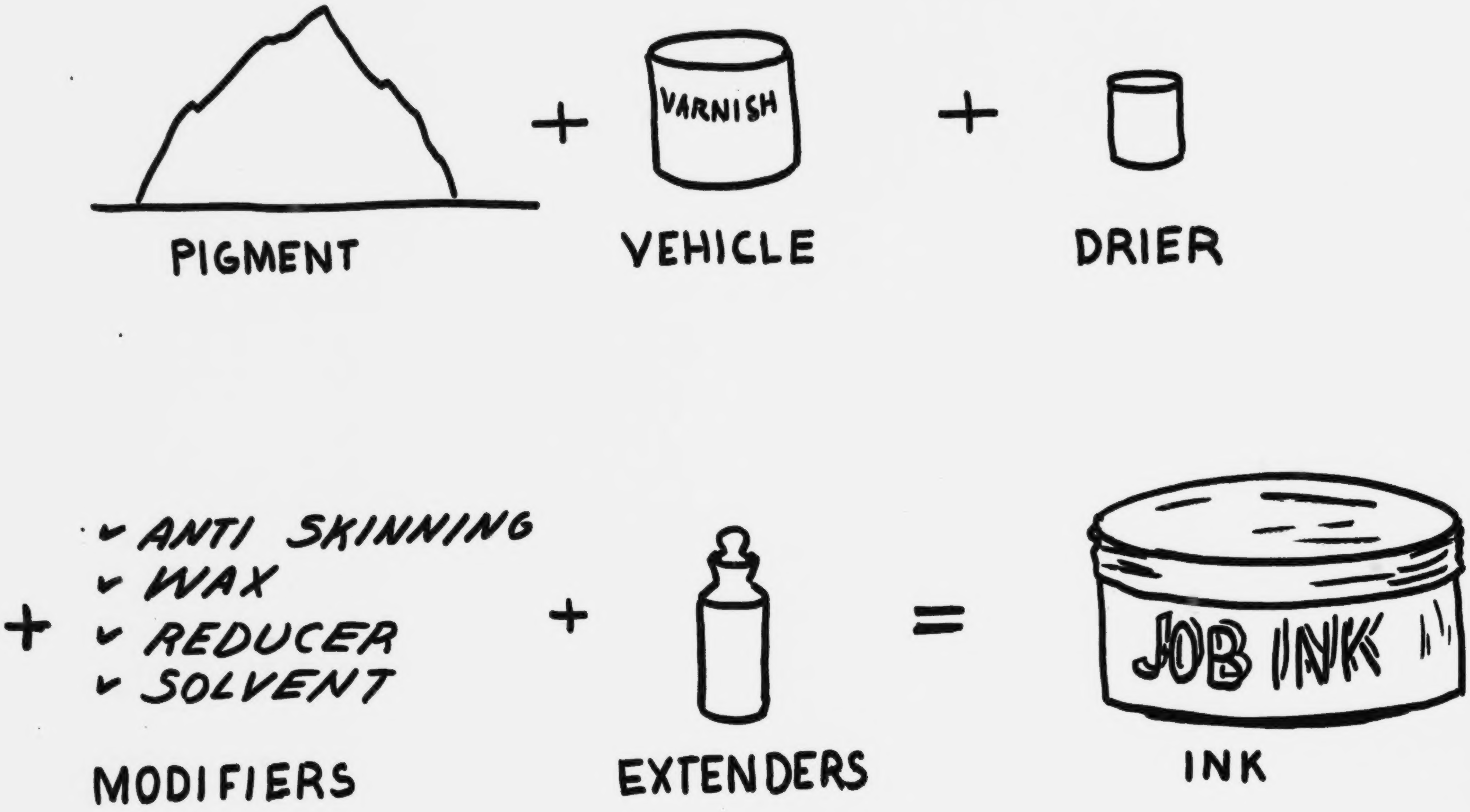

INKS ~ USES
JOB
BOND
HALFTONE
CYLINDER
NEWS
LITHO GRAPH
SPECIALTIES

CHART #1
(17"x22"
WALL CHART)

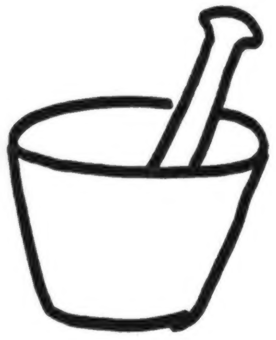
#1

INK MAKING MATERIALS

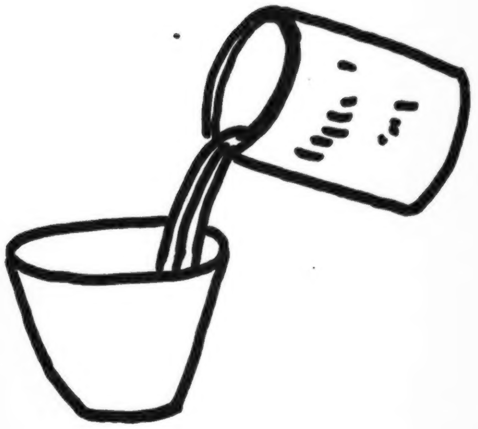

VARNISH
PIGMENT
+
VEHICLE
+
DRIER
+
ANTI SKINNING
WAX
REDUCER
SOLVENT
MODIFIERS
+
EXTENDERS
=
JOB INK
INK

INK MAKING PROCEDURES

GRIND PIGMENTS

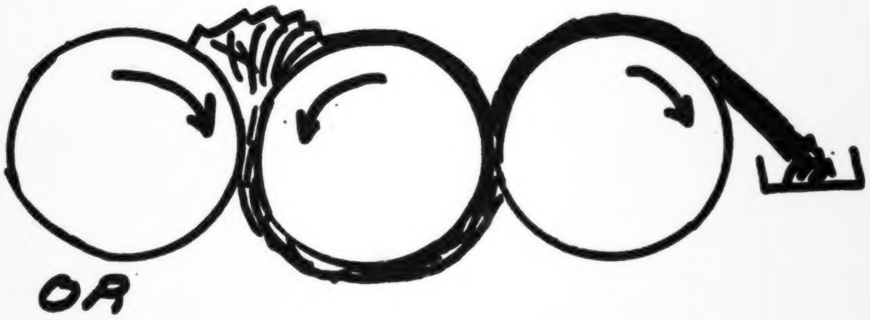


ADD VARNISH



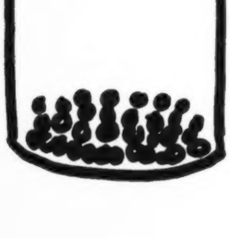
BLEND INGREDIENTS

MACHINE

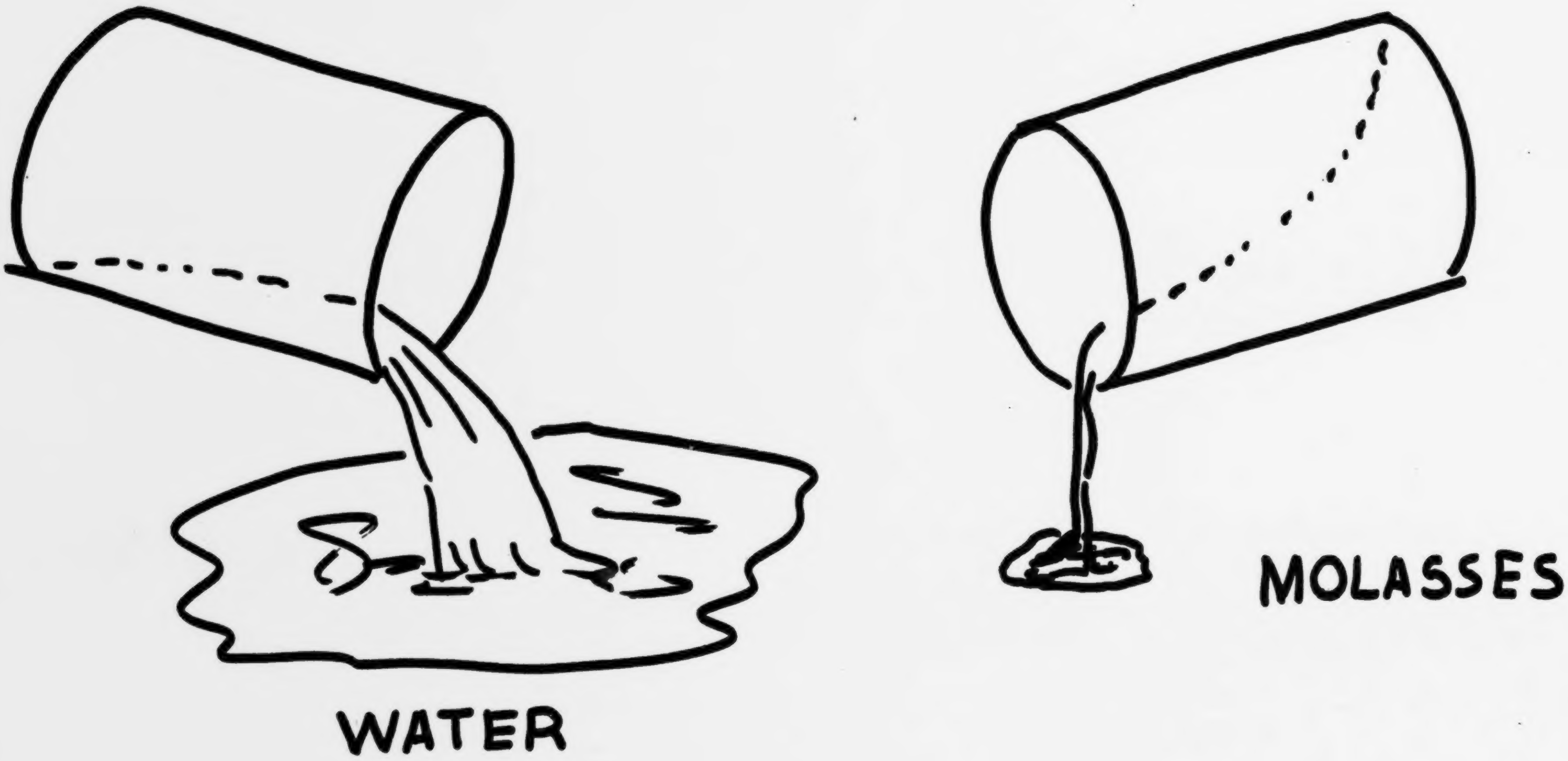


OR

STEEL BALLS
+
INGREDIENTS
+
AGITATION

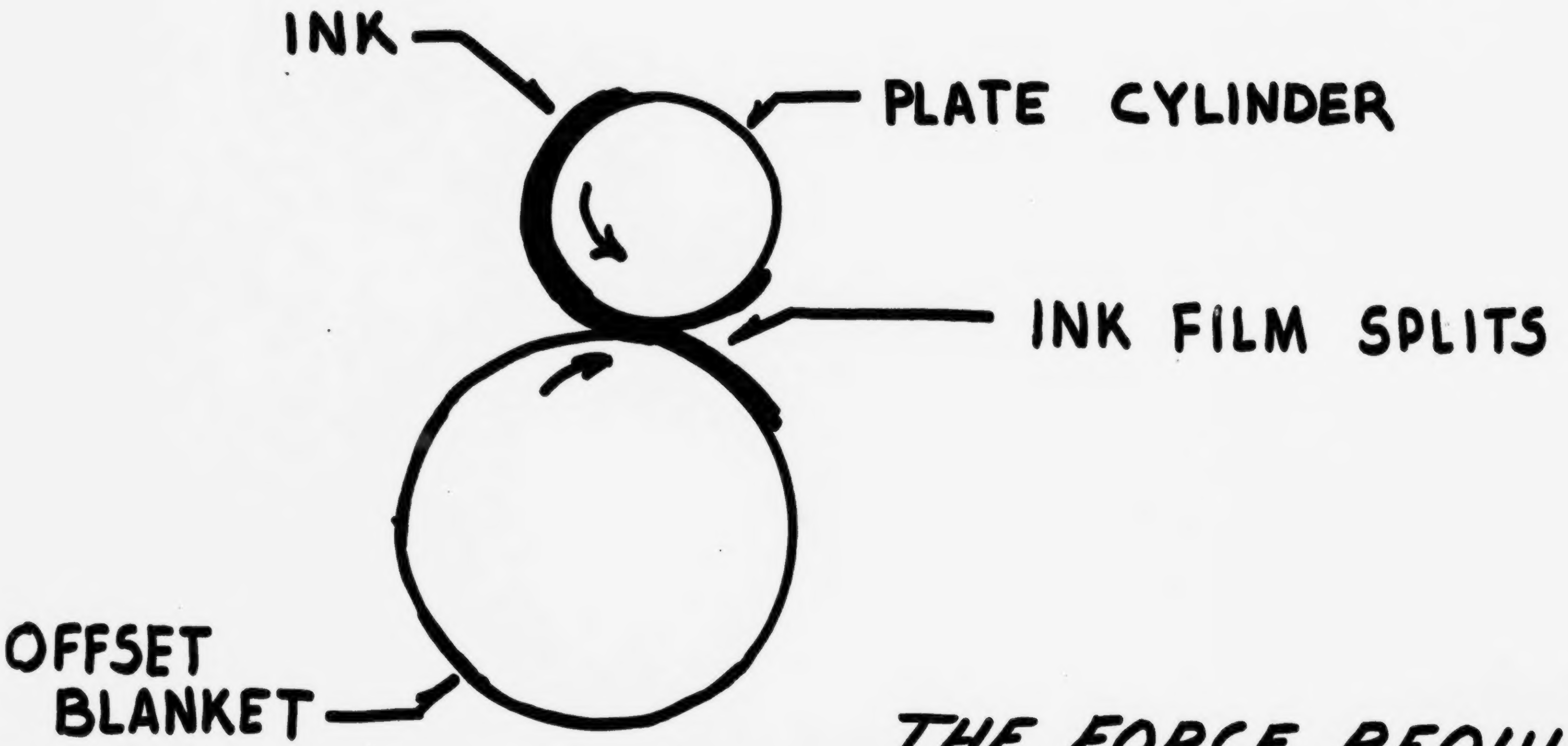


VISCOSITY


MOLASSES
WATER

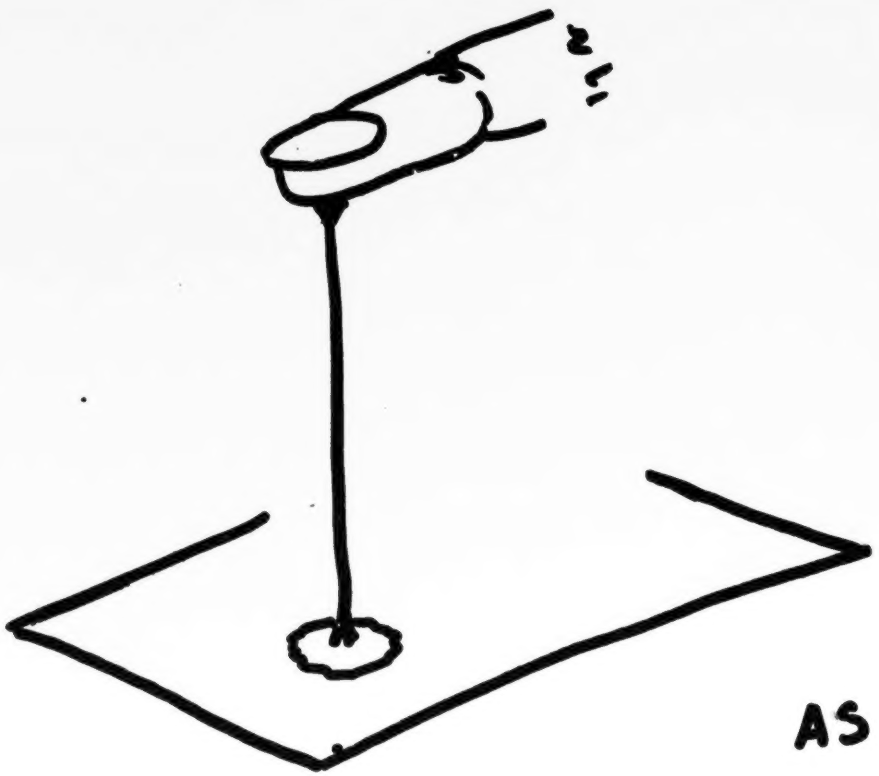
THE INTERNAL RESISTANCE OF A LIQUID TO FLOW

INK TACK


INK
PLATE CYLINDER
INK FILM SPLITS
OFFSET BLANKET

THE FORCE REQUIRED TO SEPERATE TWO SURFACES BOTH IN CONTACT WITH INK.

LENGTH OF INK



INKS BECOME LONGER AS THE INTERNAL FORCES ARE BROKE DOWN THROUGH WORKING

AS LENGTH INCREASES TACK
ALSO INCREASES

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: John Gedker
Fairmont State College
Fairmont, West Virginia

INSTRUCTIONAL LEVEL: College-Technical Education

TITLE: Strength and Durability of Paper

PRESENTATION TIME: 1 hour

INTRODUCTION:

Strength and durability of paper is usually tested under five general situations: bursting, tearing, folding, abrasion, and tensile strengths. This unit will deal with the first four of these general testing situations. The unit will include explanations of typical machines, and the theory that they operate on as well as the factors affecting the various strength factors.

OBJECTIVES:

1. To show various physical properties with the following paper tests:
    a. bursting
    b. tearing
    c. abrasion
    d. folding
2. To enable students to better understand typical testing procedures, and the industrial uses of such tests.
3. To enable students to design and use simple testing devices in their own environment.

INTER-RELATION WITH OTHER SUBJECTS:

UNTI SUBJECT AREA: Paper (Strength and Durability)

INTER-RELATION WITH OTHER SUBJECTS:
Science: micro structures of paper
Physics: Mechanics of testing machinery
Mathematics: charts, graphs, and the interpretations
Social Science: manufacturing and economics of industry

USE IN INDUSTRY:

Testing procedures are used by all industrial comsumers of paper. Tests and procedures vary according to individual uses, but all major consumers have testing facilities of some type.

MATERIALS AND EQUIPMENT:

Equipment: materials to construct it, or conventional testing machines for the four basic tests involved.
Materials: various types of paper for testing purposes. A standard or similar weight of paper to make valid comparisons on, and a sampling of ground wood paper, chemically prepared wood pulp paper, and a rag content paper (25% and 100%).

EDUCATIONAL MEDIA:

3 demonstrations: bursting, tearing, abrasion
1 chart: comparisons of papers to show folding characteristics
9 transparencies:

1. conventional bursting machine
2. homemade bursting machine
3. fiber strength comparison
4. theory of bursting tester
5. conventional tearing tester
6. homemade tear tester
7. tensile compared to tearing
8. homemade abrasion tester (theory)
9. homemade folding tester (theory)

UTILIZATION IN THE TEACHING LEARNING ENVIRONMENT:

PRESENTATION: Strength & Durability of Paper

I Bursting Strength of Paper
- Definition
- Machines
  - Conventional ....Tr. 1
  - Principles of operation
  - Homemade device............................ 2
- Factors affecting bursting strength
  - Interfiber bonding
  - Fiber strength............................ 3
  - Ratio of machine-cross grain............... 4
  - Stretch
- Bursting vs. Tensile strengths (demonstration #1)

II Tearing Strengths of Paper
- Definition
- Machines
  - Conventional............................ 5

- Principles of Operation
- Homemade devices........................... 6
- Factors affecting tearing strength
  - Cooked pulp
  - Bleached pulp
  - Acidity (demonstration #2)
  - Interfiber bonding
- Tearing vs. Tensile
  - Comparison of fiber qualities.............. 7
  - Comparison of bonding fibers

III Abrasion Resistance
- Definition
- Machines... 8
- Properties tested
  - Abrasion
  - Scuff (demonstration #3)
  - Erasibility

IV Folding Endurance of Paper
- Definition
- Machines... 9
- Properties Tested (possible demonstration)
  - Fiber length
  - Sizing and filler materials (chart #1)

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE:

Student experiments with conventional or self designed testing devices.

Student achievement on examinations concerning the physical properties as they relate to the strength and durability of paper.

UNIT EVALUATION:

Student Achievement

Pre-tests and post-test to evaluate amount of material learned.

DEFINITION OF TERMS:

Interfiber bonding: the relationship of individual fibers with each other

Fiber strength: the characteristics of each individual fiber relating to its composition, size and chemical treatment

Machine grain: the fibers align their length with the direction of travel of the paper machine.

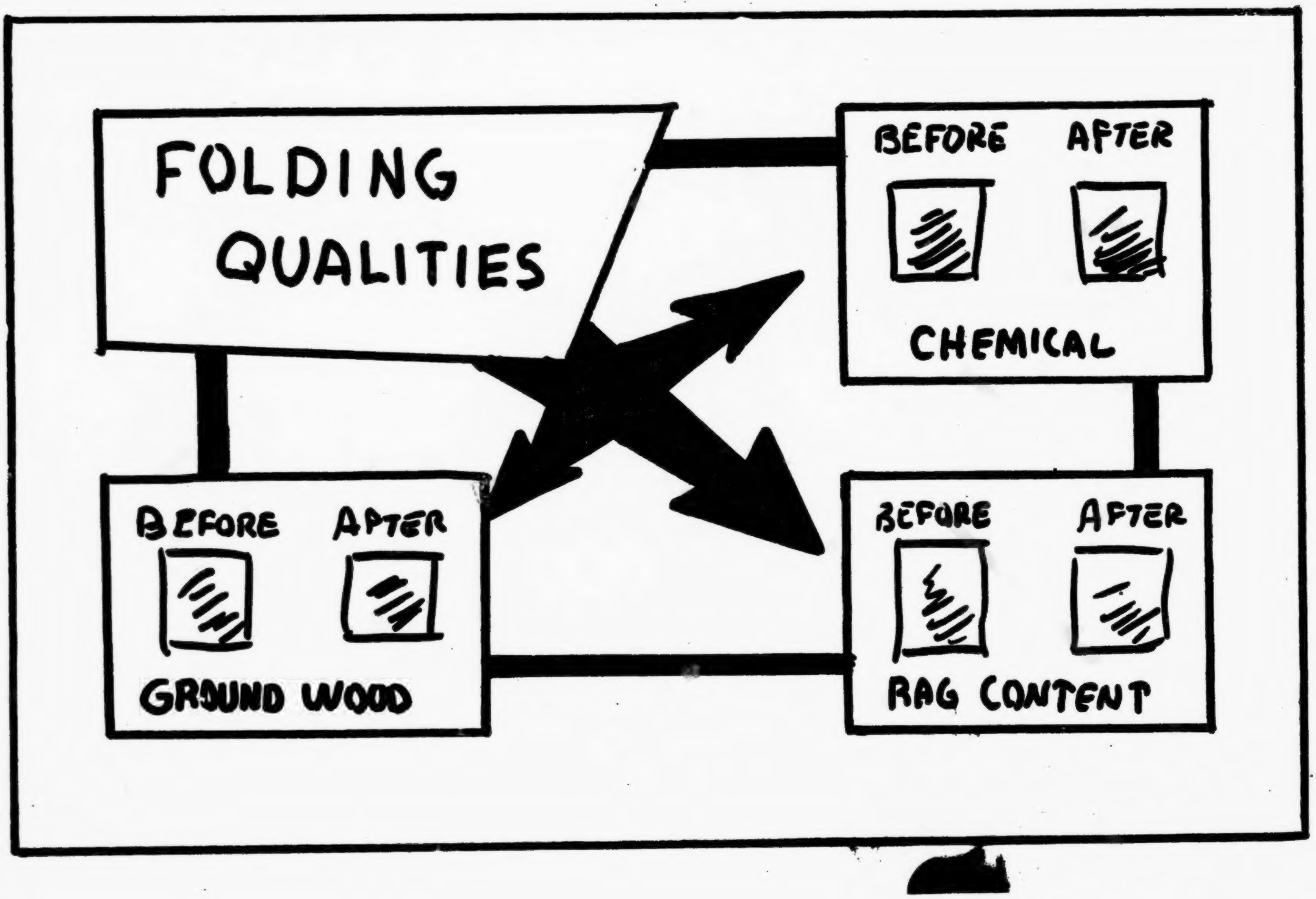
REFERENCES:

STUDENT:

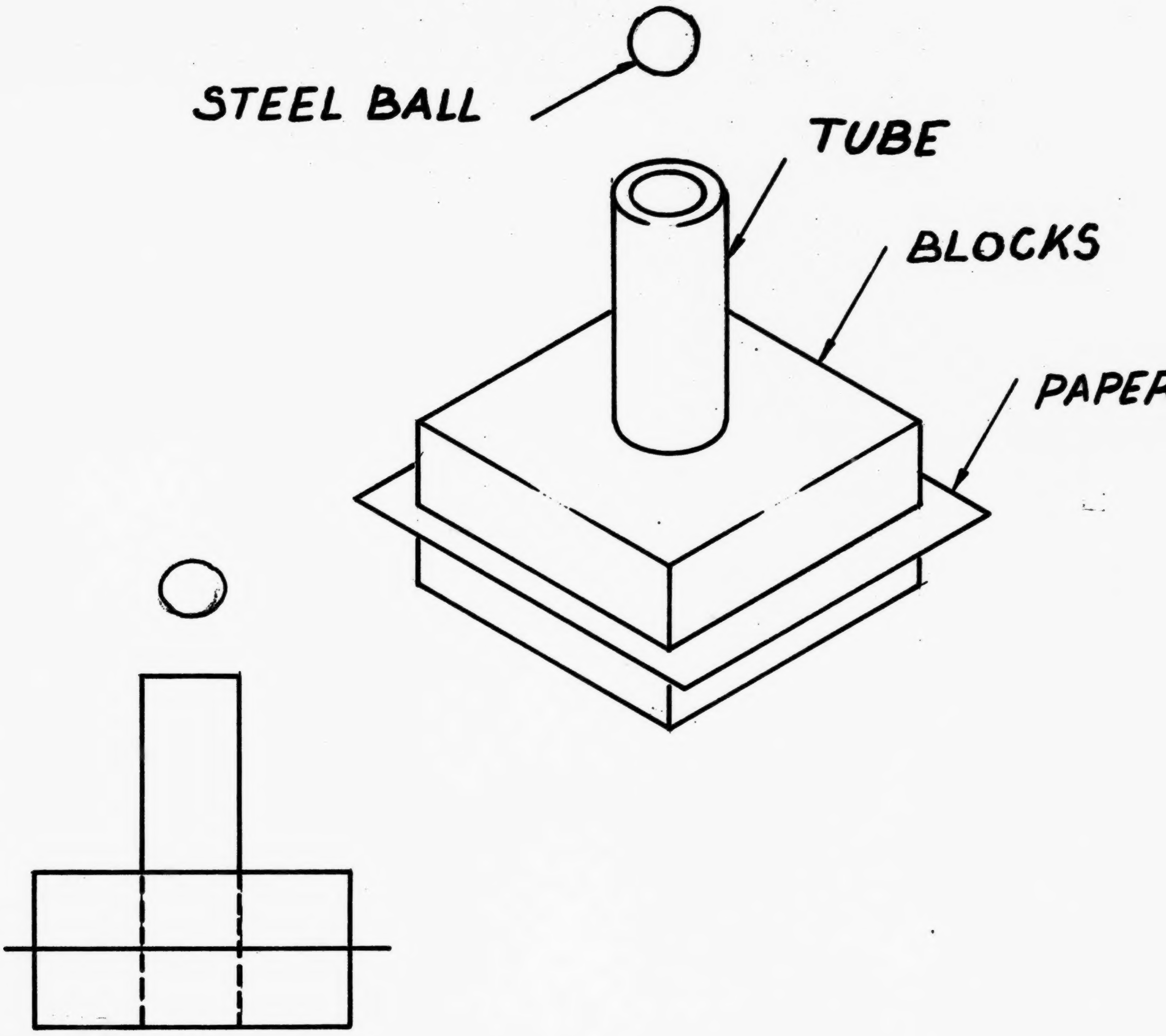
1. Cogoli, John. Photo Offset Fundamentals. 1968. (second edition)
2. Polk, Ralph. The practice of printing. 1964. Chapter 18.
3. Karch, Randolph. Printing and the Allied Trades. 1962. Chapter 20.

TEACHER:

1. Britt, Ken. Pulp and Paper Technology. 1964. Chapter 2 and 14.
2. Libby, Earl. Pulp and Paper Science and Technology. 1962. Chapter 15.
3. A.S.T.M. 1967 Manual #15.


FOLDING QUALITIES
BEFORE
AFTER
CHEMICAL
BEFORE
AFTER
GROUND WOOD
BEFORE
AFTER
RAG CONTENT

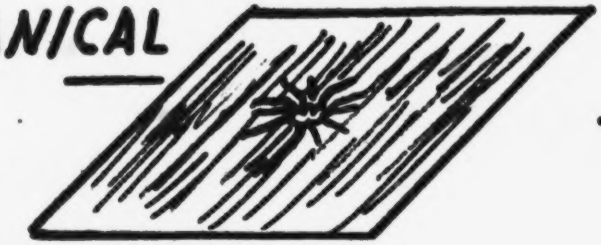
B - CHART


STEEL BALL
TUBE
BLOCKS
PAPER

GEOKER UNIT 6 - TR.#2

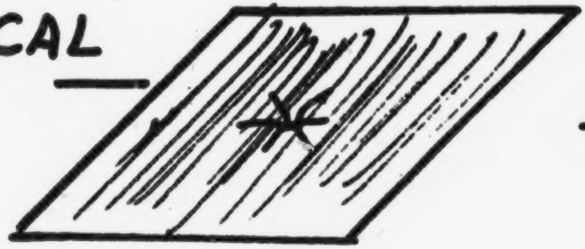
BURSTING STRENGTHS

MECHANICAL



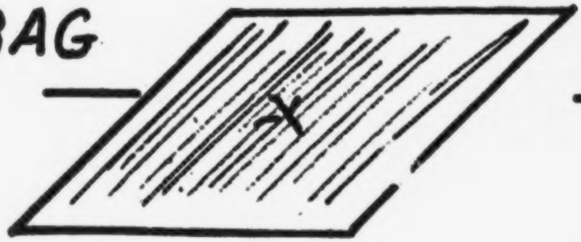
—COMPLETE FIBER RUPTURE

CHEMICAL



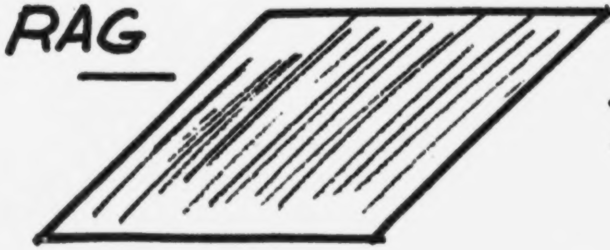
—PARTIAL FIBER RUPTURE

25% RAG

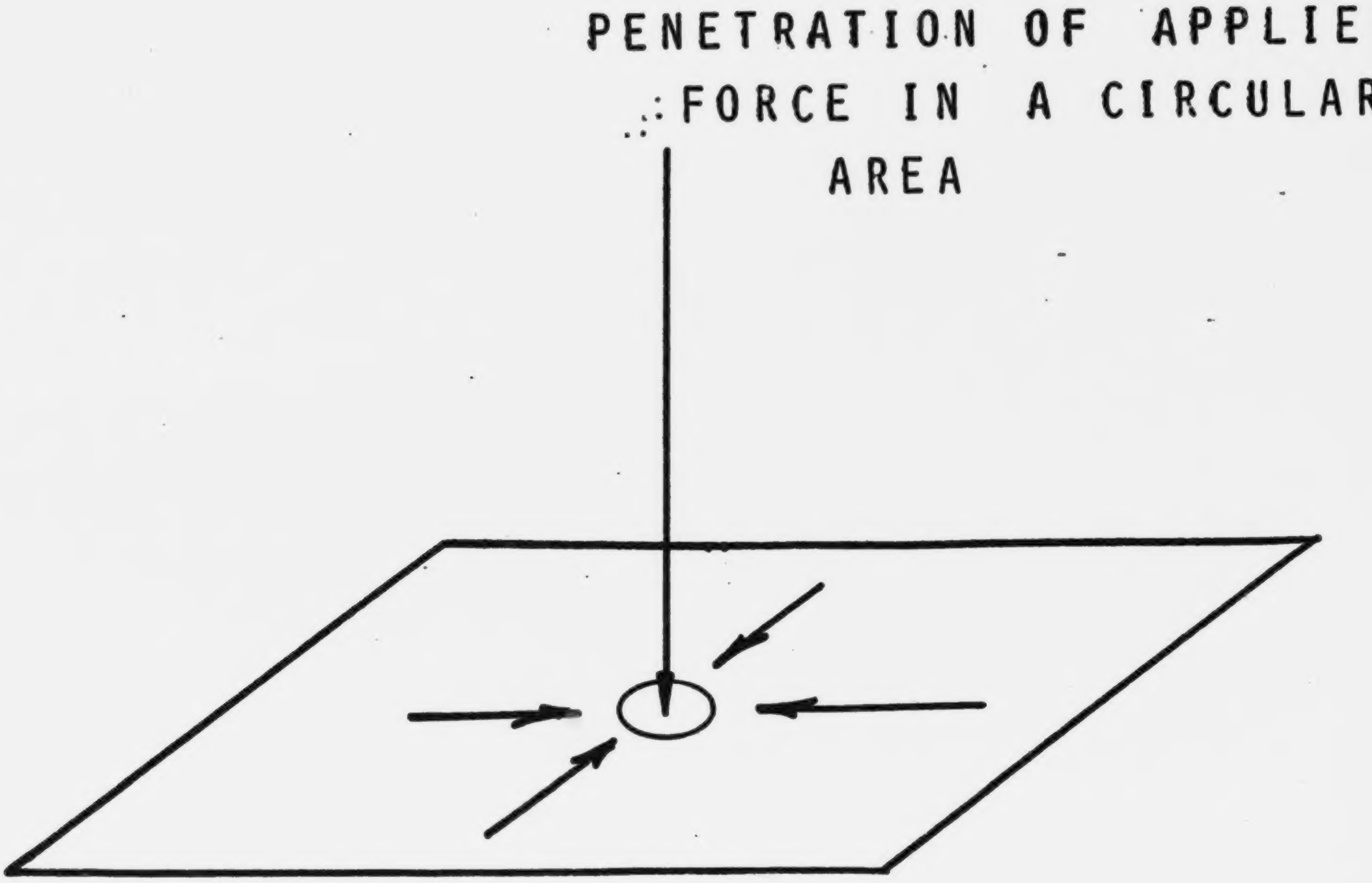


—FIBERS WEAKENED

100% RAG

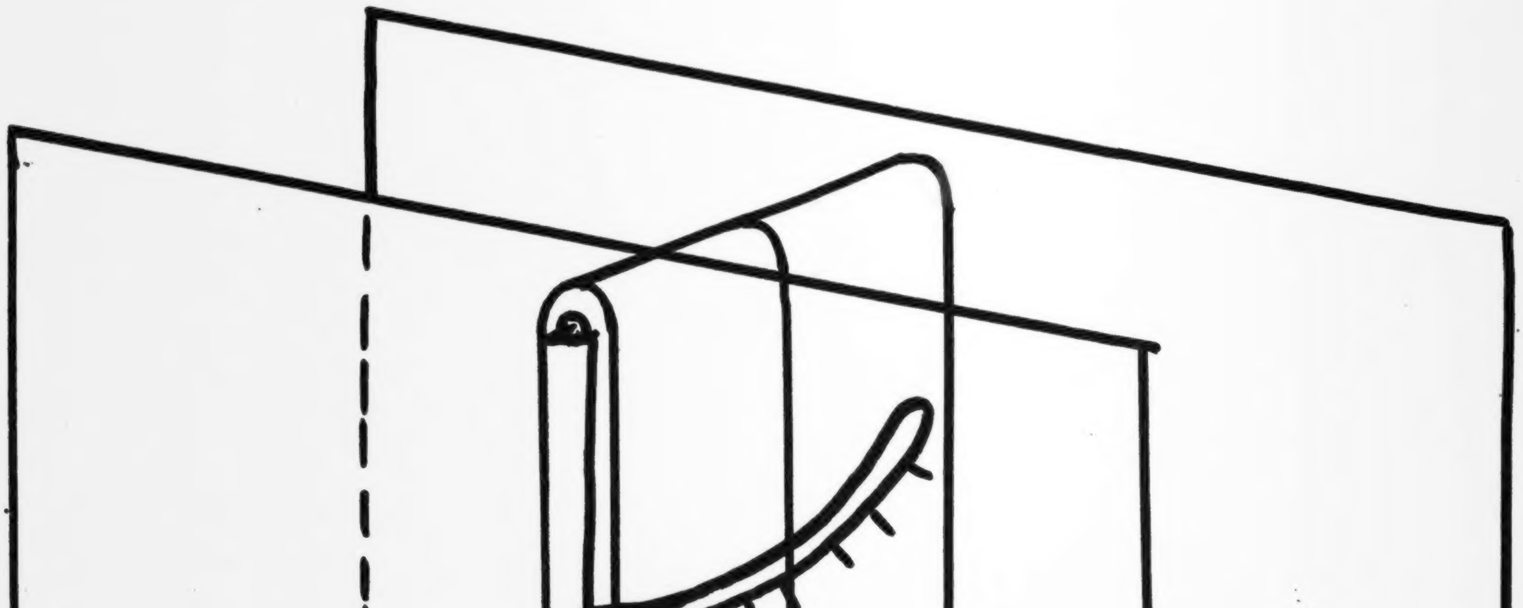


—NO VISIBLE FAILURE


PENETRATION OF APPLIE
FORCE IN A CIRCULAR
AREA

BURSTING TEST SHOWS THE
RATIO OF MACHINE AND CROSS
DIRECTION AT ONE TIME

4



TEAR
TEST

TR-6

TENSILE vs TEAR

INTERBONDING THROUGH BEATING PULP IMPROVES TENSILE STRENGTH

BUT

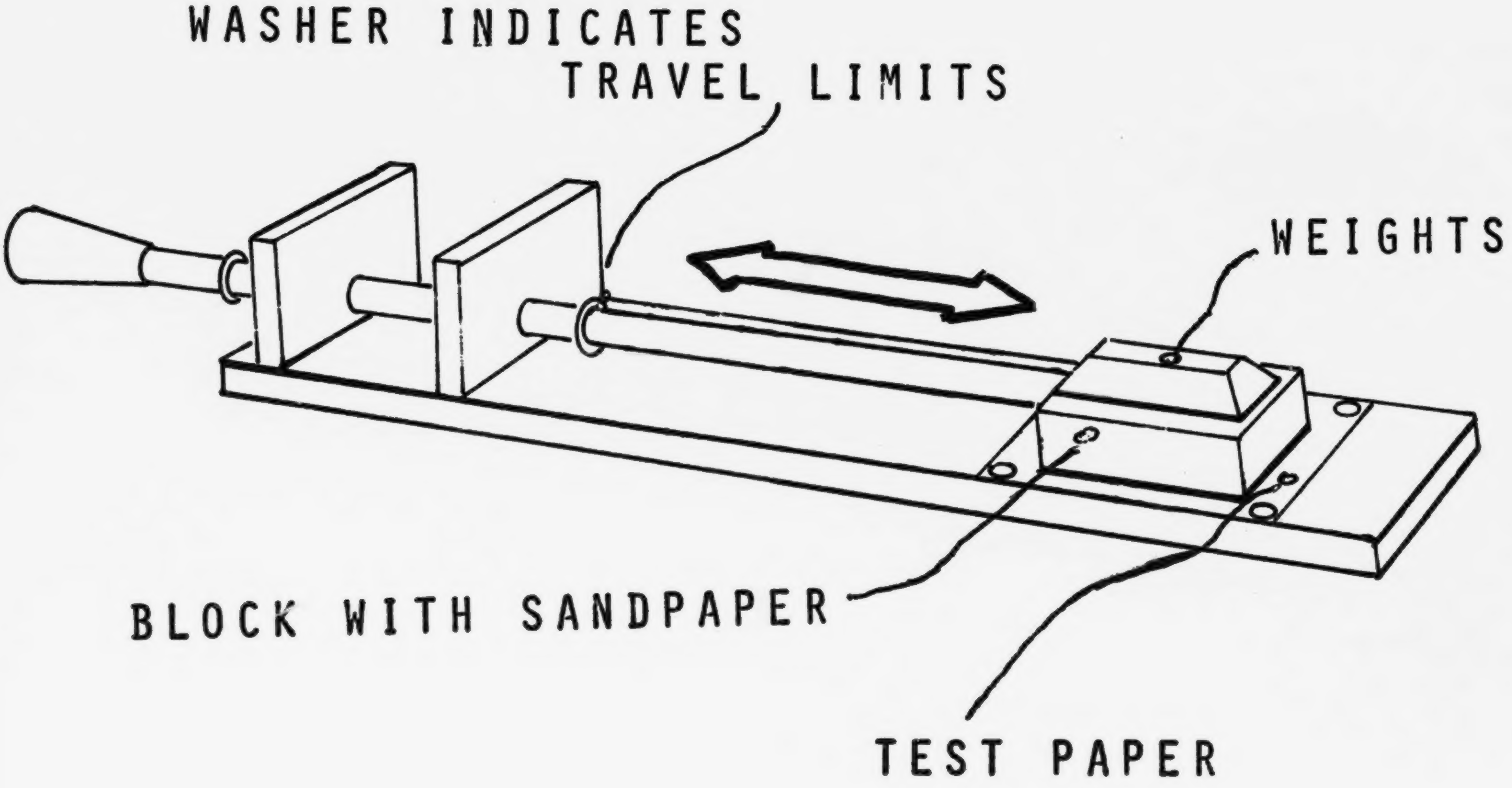
BEATING REDUCES FIBER LENGTH AND TEAR RESISTANCE

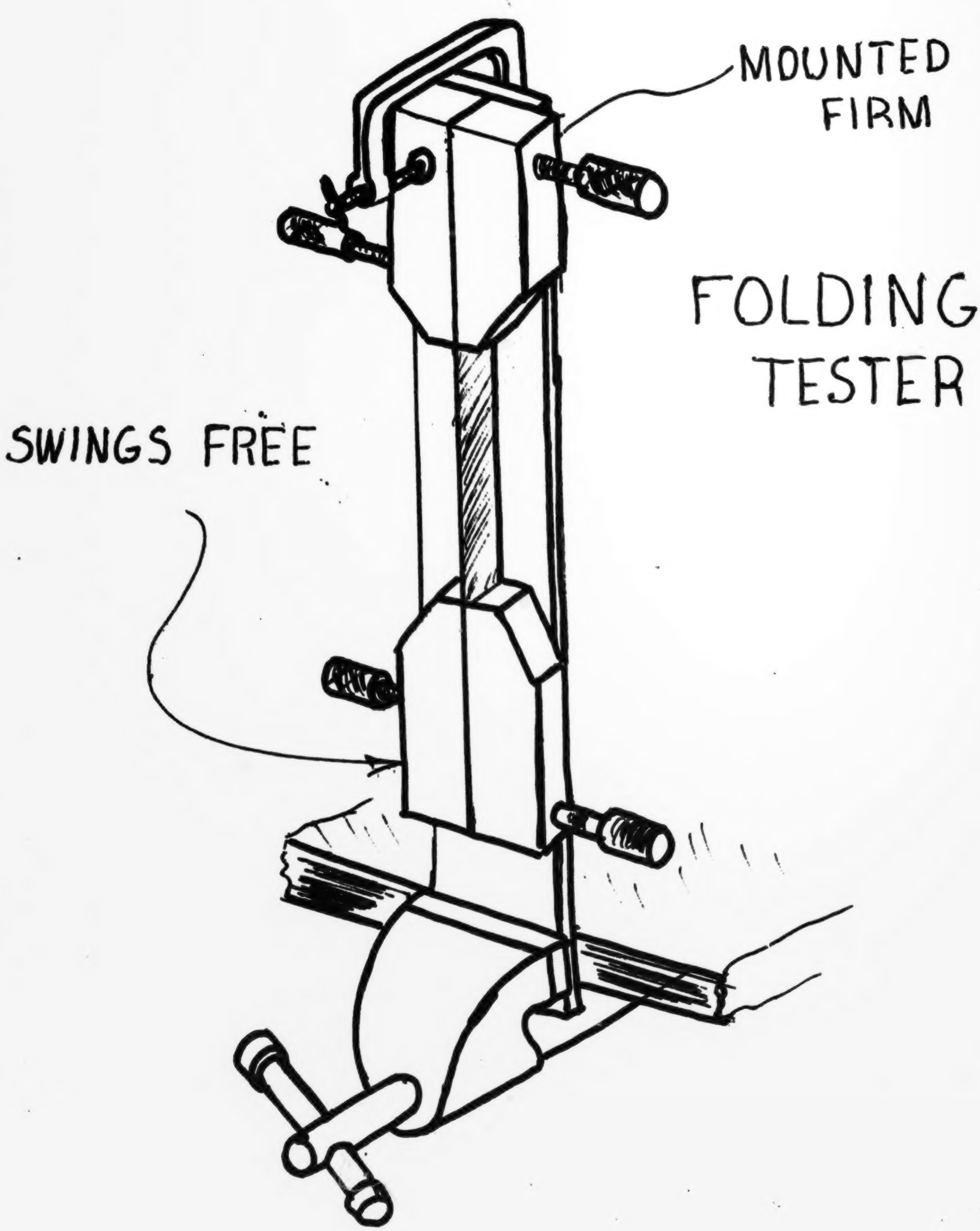
NOW WHAT?

ARTIFICIAL BONDING AGENTS AID BONDING AND REDUCE BEATING TO RETAIN LONG FIBERS

GEOKER UNIT B #7

ABRASION TESTER


WASHER INDICATES TRAVEL LIMITS
WEIGHTS
BLOCK WITH SANDPAPER
TEST PAPER


FOLDING TESTER

MOUNTED FIRM
SWINGS FREE

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: John Gedker
Fairmont State College
Fairmont, West Virginia

INSTRUCTIONAL LEVEL: College-technical Education

TITLE: Tensile Strength of Paper

PRESENTATION TIME: 1 hour

INTRODUCTION:

Strength and durability of paper is usually tested under five situations: tensile, bursting, tearing, folding and abrasion. This unit, however, will deal with tensile strength only, and the effect of paper grain, content, sizing materials and other variables.

OBJECTIVES:

1. To show differences in tensile strength when
   a. the grain runs opposite.
   b. pulp content varies
2. To discuss the surface strength of papers (transverse tensile).
3. To understand the terms and types of machines in testing tensile strength.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Paper-Tensile Strength

INTER-RELATION WITH OTHER SUBJECTS;

Science - Micro structures of paper
Physics - Mechanics of testing machinery
Math - Charts and Graphs interpretation
Social Science - Manufacturing and Economics of industry

USE IN INDUSTRY:

The producers and consumers of paper from a large percent of our total industrial society.

Paper is used for packaging, protecting, and writing, including other uses such as insulation, building paper, laminates, etc.

MATERIALS:

Various types of paper:

1. Newsprint - Mechanically ground paper
2. Chemically ground paper
3. Rag content paper

EQUIPMENT:

Materials to construct a simple version of a tensile tester

OR

A commercial tensile tester designed for paper testing.

EDUCATIONAL MEDIA:

1. Handout Sheet (General Outline)
2. Charts
3. Transparencies
4. Demonstration of tensile machine

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT:

SAFETY:

1. Precautions in the use of commercial or home made tensile testing devices.
2. Fast rate of loading may cause an undesirable reaction within the device.

PRESENTATION:

Paper Technology	Visuals
Tensile Strength	
I. Introduction	Handout
Definition of tensile strength	
Importance of tests	
Types of tensile tests	
II. Machines	
Standard commercial tester	Tr. #1
Speciality paper tensile tester	#2
Methods of recording data	#3
Stress	
Strain	Chart A
Scales used	
Home made tensile testers	#4
III. Preparation of samples	#5
Conditioning	
Humidity control	
Hysteresis	
Cutting	#6
Size	
Standards	
Rate of loading	Refer to #3

Elasticity	
Plasticity	
IV. Factors affecting tensile strength	Demonstration of tensile tester
Paper grain	
Formation	
Importance	
Hand methods of detection	#7
Paper types	
Fibers	
Strength	
Bonding	
Length	
Orientation	
Pulp Characteristics	
Pulp and grain comparisons	#8
Surface strengths	
Paper finish	Chart B
Tests	
Wax pick	
Ink pick	

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE:

1. Student experiments in testing tensile strength of paper
2. Test on knowledge of paper characteristics referring to tensile strengths

UNIT EVALUATION

Pre test -- determine previous knowledge

Post test --to determine areas that were presented poorly or not presented at all.

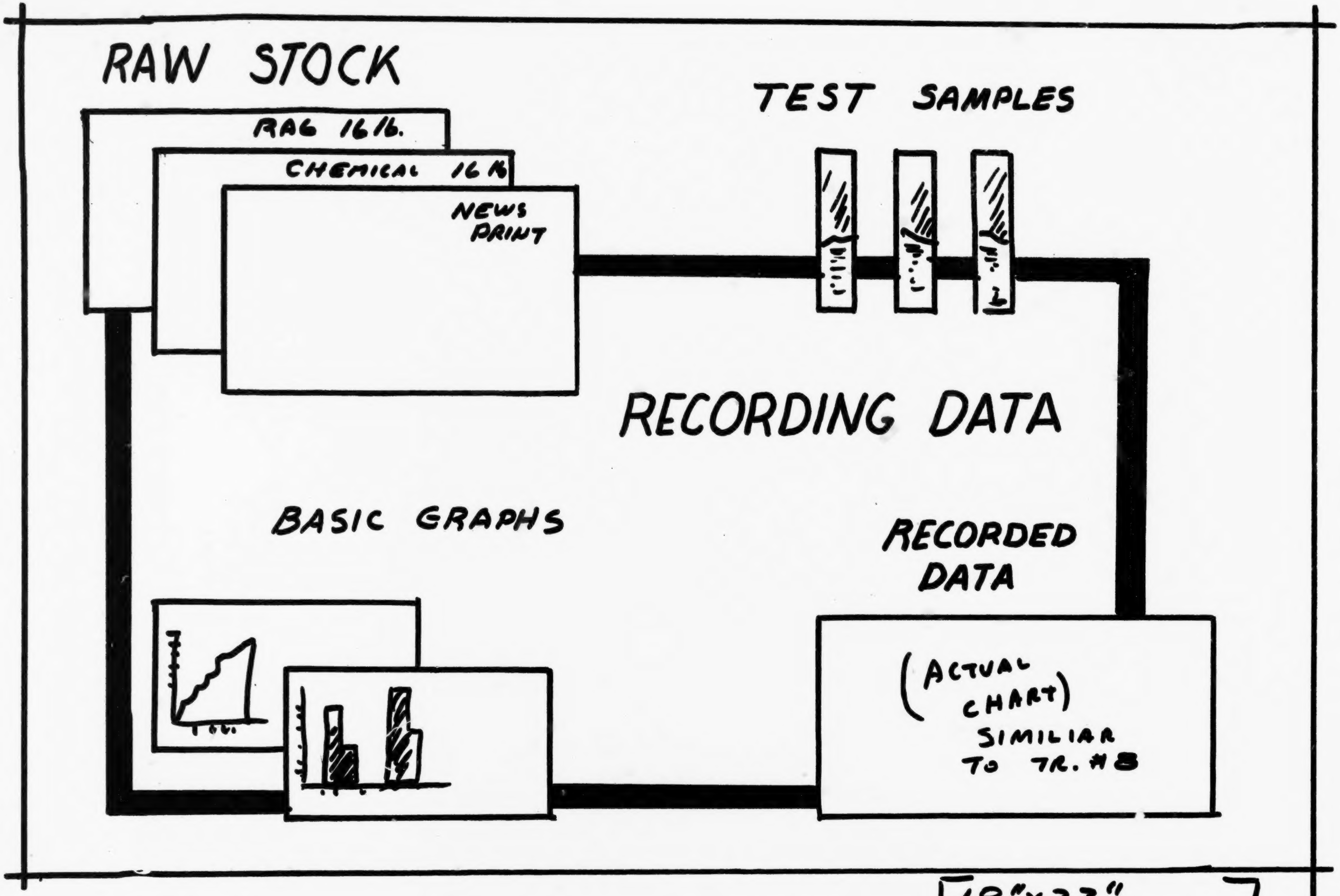
DEFINITION OF TERMS:

1. Elasticity - the amount of stress and strain that a material may take and still return to a normal shape
2. Hysteresis - the relation of moisture content of paper and the relative humidity.
3. Paper Grain - the alignment of the paper fibers in the direction of the travel of the web of the paper machine
4. Plasticity - the amount of deformation beyond elasticity until a fracture occurs in the material
5. Strain - distance that the material stretches in tensile testing
6. Stress - pounds of pressure applied in tensile testing
7. Tensile - a combination of stress and strain of a material

REFERENCES:

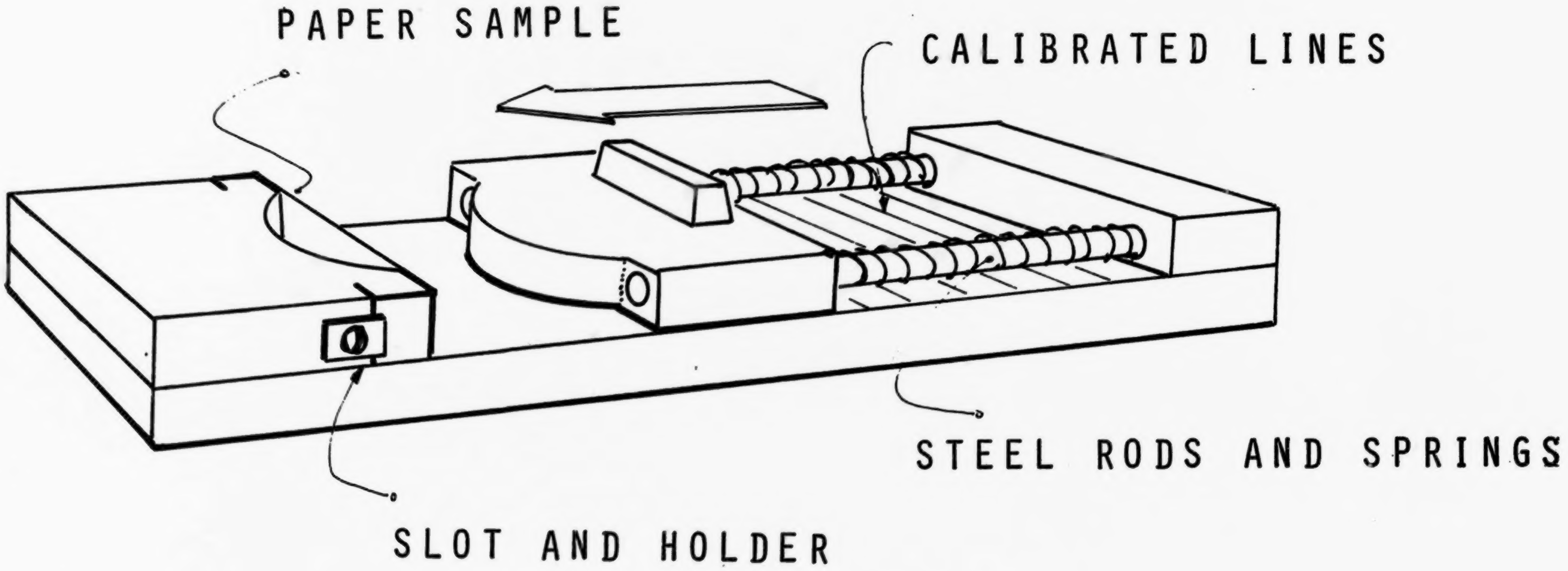
STUDENT:
1. Cogoli, John. Photo Offset Fundamentals, 1968 Ed.
2. Polk, Ralph W. The Practice of Printing, 1964, ch. 18.
3. Karch, Randolph, Printing and the Allied Trades, 1962, ch. 20.

TEACHER:
1. Britt, Ken. Pulp and Paper Technology, 1964, ch. 2, 14.
2. Libby, Earl C. Pulp and Paper Science and Technology, 1962, ch. 15.
3. ASTM Manual #15, 1967.
4. Johnson, Everett. Strength Tester, 1967 NDEA Materials Institute.

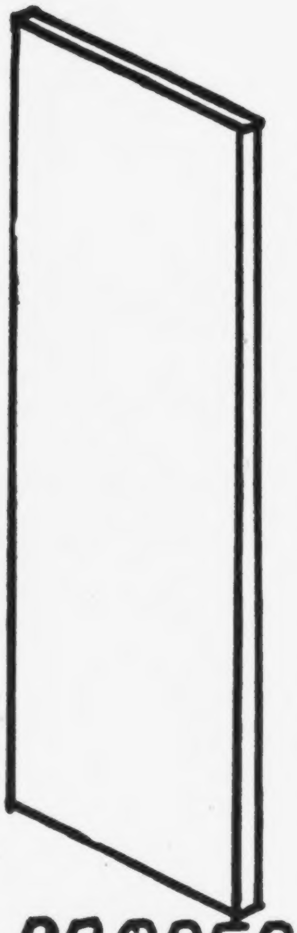

RAW STOCK
RAG 16 lb.
CHEMICAL 16 lb
NEWS PRINT
TEST SAMPLES
RECORDING DATA
BASIC GRAPHS
RECORDED DATA
(ACTUAL CHART) SIMILIAR TO TR. #8

[18"x22" WALL CHART]

PAPER TESTER - GRAIN INDICATOR

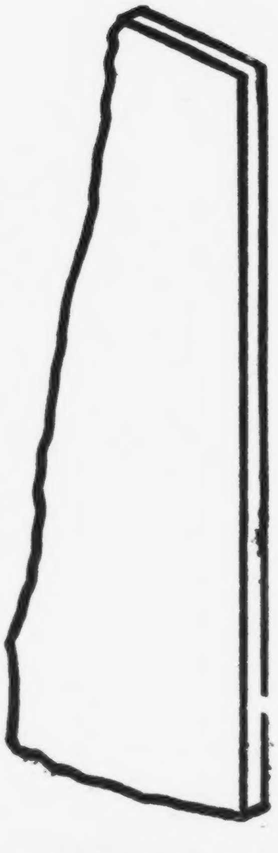

PAPER SAMPLE
CALIBRATED LINES
STEEL RODS AND SPRINGS
SLOT AND HOLDER

PREPARATION OF SAMPLES



PROPER

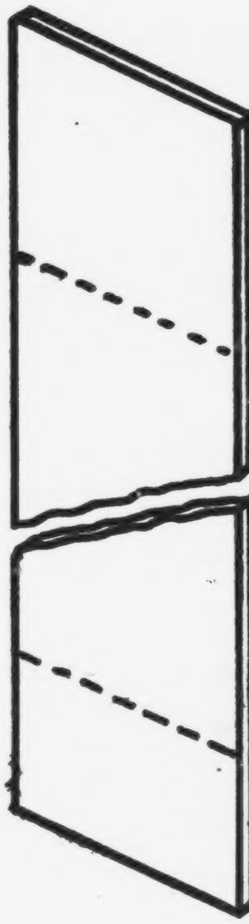
- STRAIGHT EDGES
- UNIFORM WIDTH
- NO FLAWS



IMPROPER

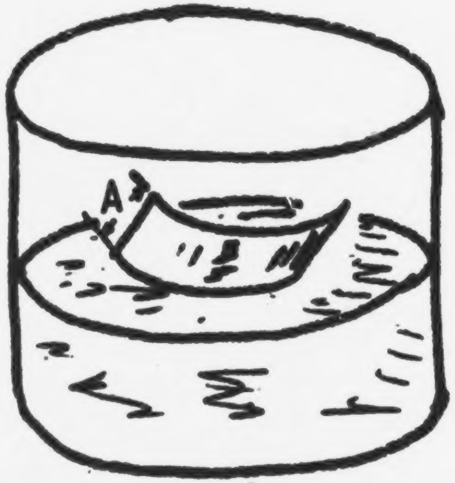
EXPECTED RESULTS

BETWEEN JAWS

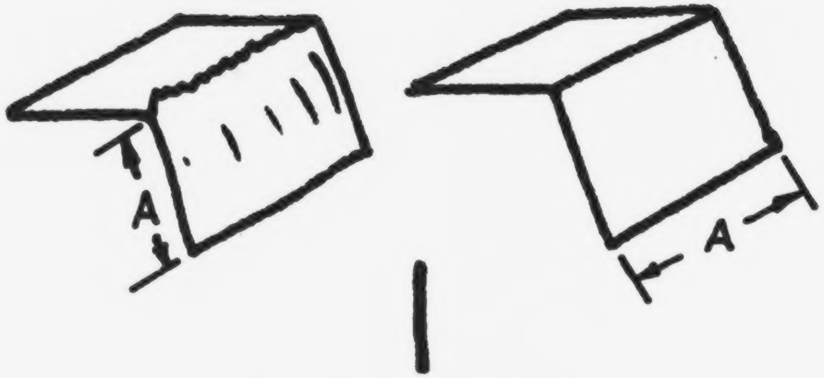


HAND METHODS TO DETERMINE GRAIN

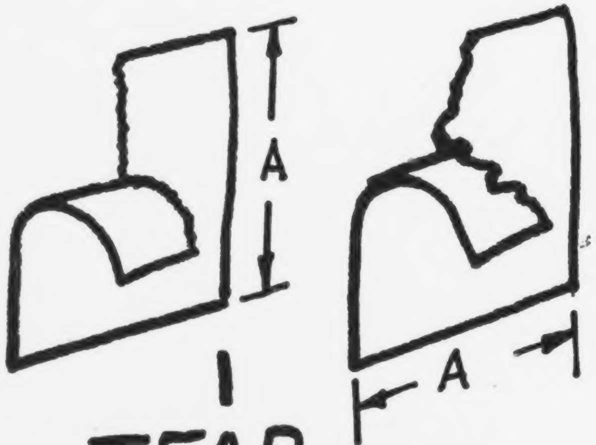
A. GRAIN DIRECTION



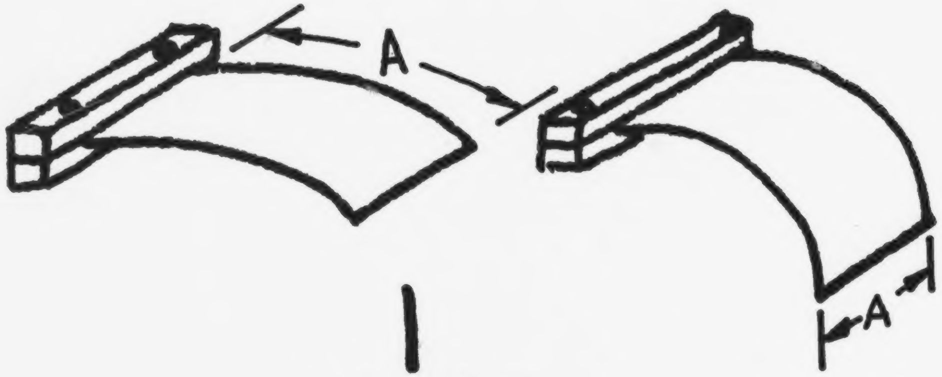
WATER-CURL



FOLDING

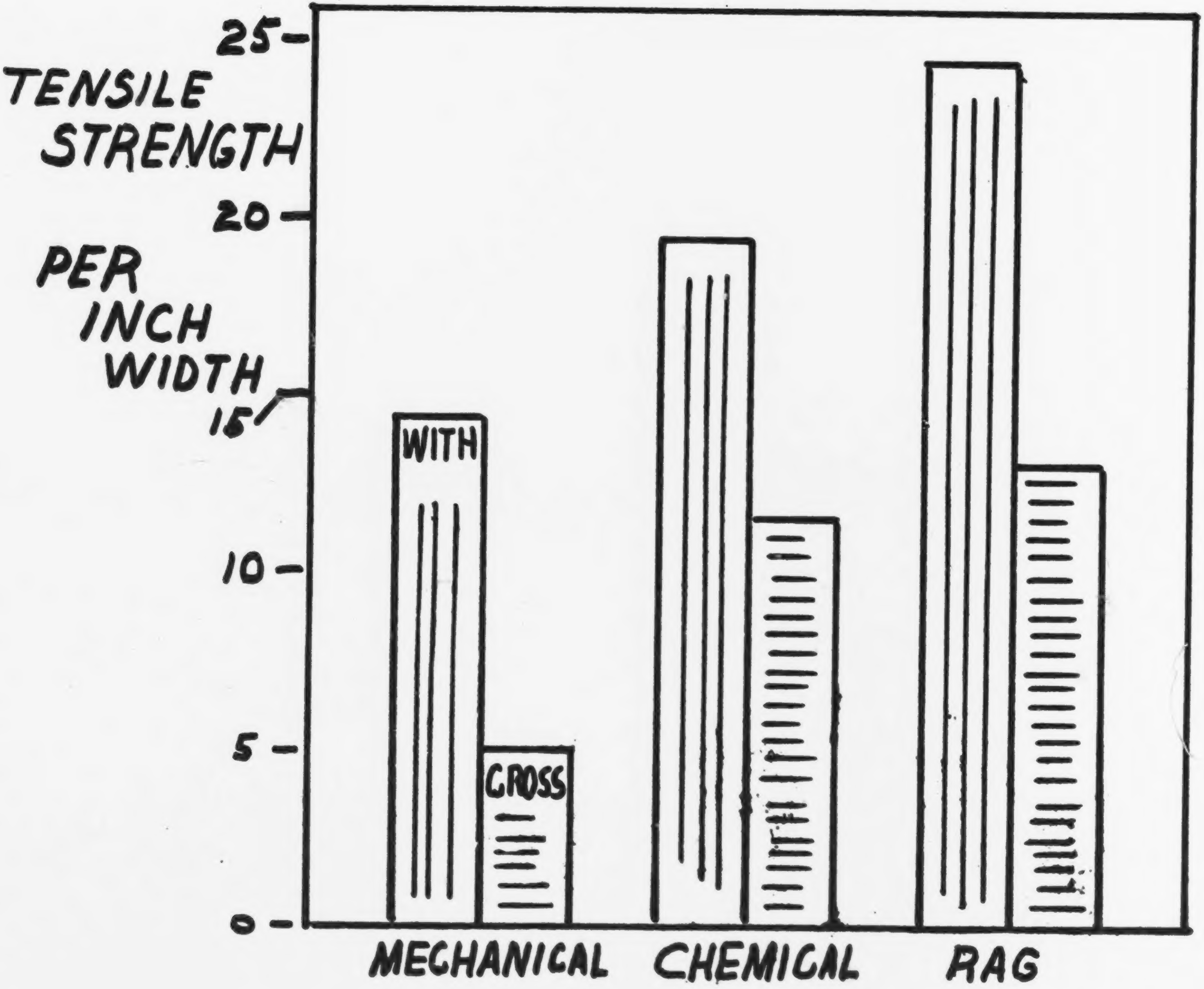


TEAR

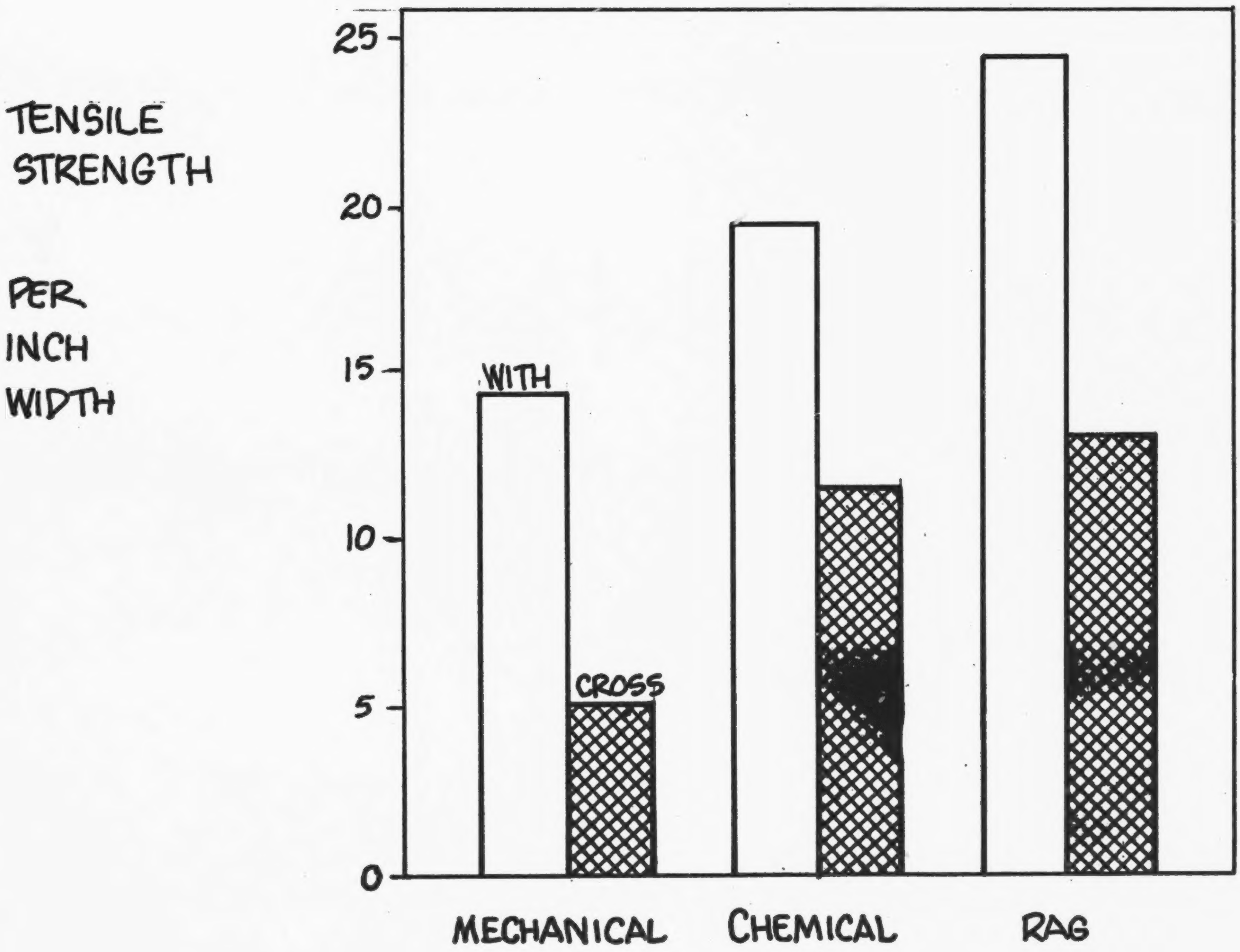


DROOP

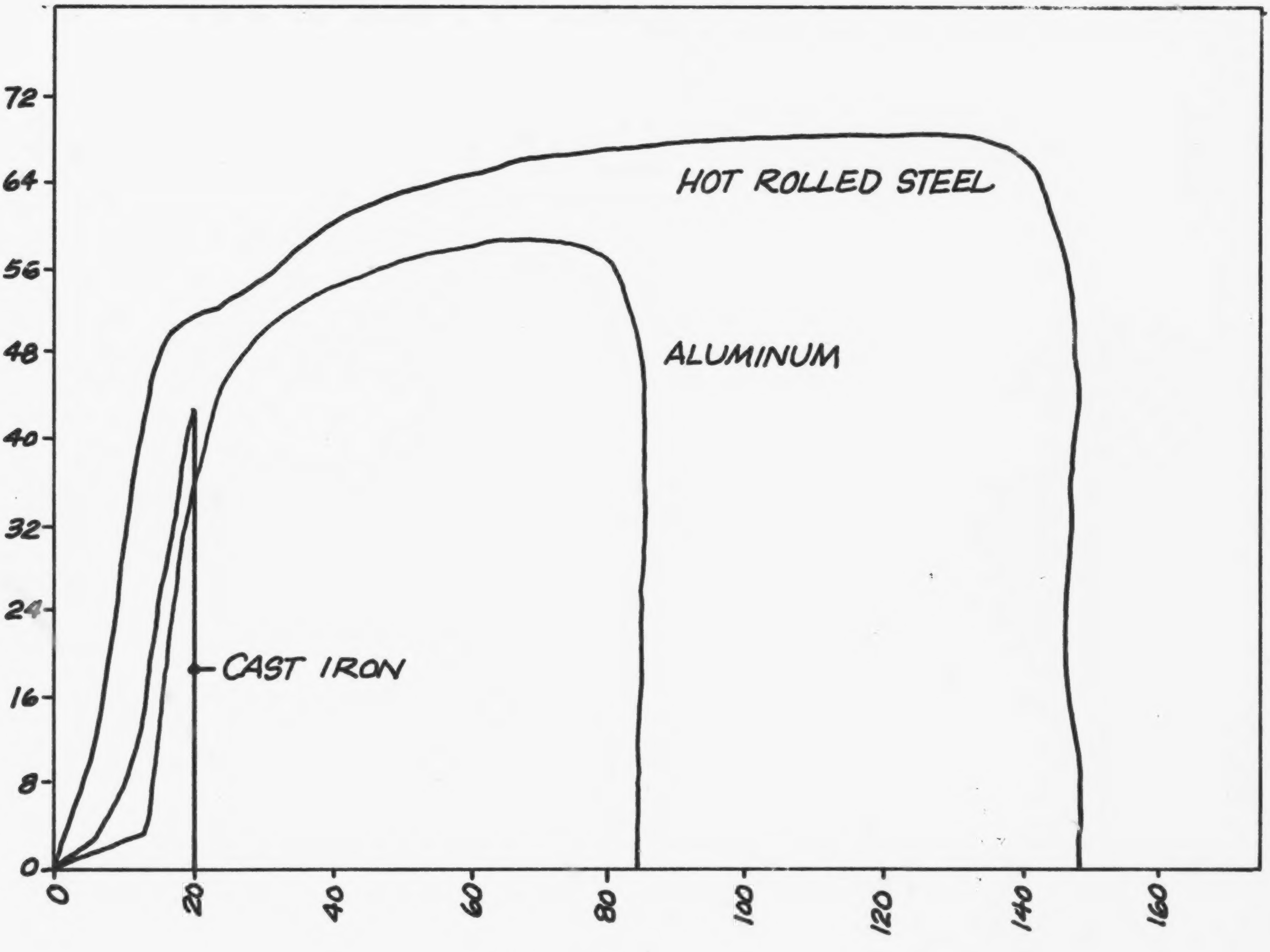
BREAKING POINT COMPARING GRAIN



BREAKING POINT COMPARING GRAIN



TENSILE TESTS



FUELS AND LUBRICANTS

INDUSTRIAL MATERIALS STUDY

INTRODUCTION TO PETROLEUM

The term petroleum and oil are many times used to mean the same thing, but this is not the case. Oils are liquids that may be obtained from several sources, such as plants, animals, fish, and also petroleum. Petroleum itself is the oil that is obtained from the earth. Early in its history it was named rock oil which in Latin is petra oleum which became the term petroleum. . .

Petroleum as it comes from the earth in its crude form is generally a dark colored liquid, but this can vary greatly from a colorless, odorless, gas known as natural gas to a dark solid known as natural asphalt. A form of petroleum can even be obtained from materials such as oil shale, gilsonite, and tar sand. These materials can be found in many different areas of the world.

In its broadest sense, the term petroleum covers many materials. However, to the petroleum industry the term means a liquid raw material from which a refinery makes hundreds of different products.

I. Chemical Composition
  A. Petroleum Hydrocarbons
    1. Structure of a hydrocarbon molecule
      a. Carbon atom
      b. Hydrogen atom
      c. Valence
      d. Bonding
    2. Characteristics and size of molecule
      a. Gas
      b. Liquid
      c. Solid
    3. Isomers
      a. Thousands of known isomers
      b. Millions theoretically possible
    4. Paraffin hydrocarbons
      a. Saturated molecules
      b. Straight chain structure
      c. Chemically inactive
    5. Olefin Hydrocarbons
      a. Unsaturated molecules
      b. Chemically active and unstable
      c. Raw material for petrochemicals
    6. Naphthene hydrocarbons
      a. Saturated molecule
      b. Closed ring or cycloparaffin

        7. Arometic Hydrocarbons
            a. Unsaturated molecules
            b. Ring structure molecules
            c. Stable solvents
        8. Other petroleum constituents and impurities
            a. Sulphur compounds
            b. Nitrogen compounds
            c. Oxygen compounds
            d. Metal compounds
            e. Mineral salts and water
    B. Synthetic Hydrocarbon Compounds
        1. Products from petroleum hydrocarbon number 3,000 or more.
        2. Cracking and production of petrochemical bases.
        3. Comparison of petroleum and coal tar in production of synthetics.
        4. Examples of synthetic products
            a. TNT
            b. Orlon
            c. Anti-freeze
            d. Dacron
            e. Nylon
            f. Cellaphane
            g. Photo film
            h. Teflon
            i. Mylar
            j. Plexiglass
            k. Lucite
            l. Butyl rubber
            m. Neoprene
            n. DDT
            o. Detergent
            p. Many others
II. Crude Oil
    A. Occurrence of Petroleum
        1. Second most plentiful liquid in the world.
        2. Petroleum formation
            a. Organic tissue
            b. Exact process not known
            c. Bearing rock formation
        3. Location within earth's structure
            a. Marine sediment
            b. Rock of marine origin
            c. Sea life
            d. Tissue not decomposed by oxygen
            e. Porous rock called reservoir rock

        - f. Sandstone and limestone
        - g. Source stone and traps
    - 4. Traps
        - a. Anticline
        - b. Salt dome
        - c. Fault trap
        - d. Stratigraphic trap
    - 5. Major area locations
        - a. Texas and Gulf coast
        - b. Middle East
        - c. North American Mid-continent
- B. Petroleum Exploration
    - 1. Oil exists where there is no trace on the surface to indicate it.
    - 2. Some surface may give a clue.
    - 3. No positive location methods
    - 4. Geological technology
        - a. Tells where oil might be
        - b. Underground formations
        - c. Seismic surveying
        - d. Gravitymeter Surveying
        - e. Magnetometer surveying
    - 5. Well logging
- C. Drilling for Petroleum
    - 1. Well depth range from near surface to 20,000 feet.
    - 2. Cable tool drilling
        - a. Originated in China centuries ago
        - b. Pounding action
    - 3. Rotary drilling
        - a. Developed about 1900
        - b. First well in Texas 1901
        - c. Ten times faster than cable
        - d. Rotary cutting or grinding action
    - 4. Marine drilling
    - 5. Coring
    - 6. Directional drilling
    - 7. Completion of a well
        - a. Flow test
        - b. Fracturing
- D. Production
    - 1. Gas cap drive
    - 2. Dissolved-gas drive
    - 3. Water drive
    - 4. Secondary recovery
    - 5. Artificial lift
    - 6. Oil, gas, and water separation

- E. Oil Shale
  - 1. Large deposits in Colorado, Utah and Wyoming
  - 2. Yield - 2 barrels per ton
  - 3. Kerogen is unlike crude oil
  - 4. Processing not yet economical
- III. Petroleum Refining
  - A. Distillation
    - 1. Simple distillation (early process)
      - a. Shell stills
      - b. Rerun
      - c. Continuous distillation in shell still
    - 2. Fractional distillation (modern)
      - a. Pipe still furnace
      - b. Bubble tower
      - c. Bubble caps
      - d. Temperature gradient and fraction boiling range
      - e. Atmospheric distillation
      - f. Vacuum distillation
      - g. Stripping and rerunning
  - B. Refining Gasoline
    - 1. Cracking
    - 2. Catalytic Cracking
    - 3. Reforming
    - 4. Polymerization
    - 5. Alkylation
    - 6. Isomerization
    - 7. Octane numbers
    - 8. Additives
    - 9. Gasoline blending
  - C. Refining lubricating Oils, Waxes, and Greases
    - 1. Dewaxing
      - a. Cold Press
      - b. Filtration
    - 2. Solvent Extraction (impurities)
      - a. Phenol treating
      - b. Liquid sulphur dioxide treating
      - c. Furfural treating
      - d. Propane de-asphalting
      - e. Duosol process
    - 3. Solvent dewaxing
      - a. Solvents
        - (1) naphtha
        - (2) Propane
        - (3) Sulphur dioxide
        - (4) Acetone benzene
        - (5) Barisol
        - (6) Methyl-ethyl-ketone (MEK)
      - b. Hot and cold solvent treating

4. Wax manufacture
    a. Wax sweating
    b. Wax recrystallization
5. Grease manufacture
    a. Lubricating oil with thickening agent
        (1) Lime soap greases
        (2) Soda soap greases
        (3) Lithium and barium soap greases
    b. Cold set greases
    c. Batch manufacture
    d. Continuous manufacture

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: Ned Ellsworth
Cortez High School
Phoenix, Arizona

INSTRUCTIONAL LEVEL: High School

TITLE: Experiments with Lubricating Oils

PRESENTATION TIME: 5 hours

INTRODUCTION:

It is important that everyone has general information as to how various materials are used to reduce friction and the advantages that one may have over another. Lubricants have many important functions in an automobile and other types of machinery. The study of lubricants involves the various desirable properties a lubricant must possess in order to accomplish its purpose. Such problems as viscosity, flash and fire points, pour points, load carrying characteristics, oxidation characteristics, the role of various additives and/or detergents, should be taken into account when lubricating mechanisms. As we study lubricating oils we should concern ourselves with the working environments that they work in and necessary modifications that are necessary in order for the oils to perform.

OBJECTIVES:

1. To show what wetting is and the wetting abilities of different petroleum products
2. To show the flash point of oil and make this concept more meaningful
3. To show the foaming action that can take place in a crankcase
4. To show the effects of pressure on the load carrying ability of oils
5. To show visually what viscosity is
6. To show the effect of temperature on the viscosity of oil
7. To teach to the student the importance of proper maintenance of mechanical equipment
8. To help promote interest and motivation toward further study and investigation in the field of lubricants

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Automotives

INTER RELATION WITH OTHER SUBJECTS:

Metals people must become thoroughly versed with the working mechanisms of lubricants, especially such mechanisms as adhesion, cohesion, heat flow, temperature tolerances, compatibility with the metals being worked, possible chemical reaction, and possible fluid degradation due to improper cleaning or treatment. In addition, the typical oils, mixtures, emulsions and other special compositions should be studied in terms of their respective values and graphic arts areas.

USE IN INDUSTRY:

The fundamental principles of reducing friction when moving parts are put into motion is of interest to both industry and society. For example, we may lubricate the lock on a car door with a liquid and thus cause a dust collection problem; on the other hand, the same door lock could be lubricated with a solid lubricant such as graphite or granular teflon without causing a soiled condition.

The knowledge of viscosity of oils, load carrying capacity, flash point, additives, detergents, and oxidation characteristics, help the technicians of industry to choose the proper oils for given situations, thus preventing many expensive breakdowns.

MATERIALS AND EQUIPMENT:

motor oil - 10, 20, 30, 10-30, 40, one qt. ea.
additives- STP, etc.
cutting oil
bunsen burner
wetting tester - picture included
eye dropper
stir sticks
blendor
overhead projector
small funnel
400mm beakers - 6
thermometer
hot plate
stand to hold beakers
viscosity measuring cup
stop watch
rags - 1/2 doz.
asbestos gloves
small piece of glass 4x4
one pt. gas
drill press
torque wrench
load testing device - picture included
flash tester (small test flame)
stand to hold thermometer

EDUCATIONAL MEDIA:

Overhead transparencies: (graphs)
- Temperature vs. Viscosity
- Load vs. Torque

Educational films:
- Frontiers of Friction
- Pressures in Fluid at Rest
- Oil Films in Action
- Refining oil for Energy

UTILIZATION IN THE TEACHING LEARNING ENVIRONMENT:

SAFETY:

Use asbestos gloves when moving the beakers in the viscosity and temperature tests.

PRESENTATION:

First Day:
1. Introduction
   - A. Opening Remarks
   - B. Content of Unit
2. Film
   - A. Frontiers of Friction
   - B. Oil Films in Action
3. This first day will probably be omitted if this unit is preceded by other units on Petroleum products.

Second Day: Demonstrations (by instructor)
1. Wetting

   Wetting is the action a liquid has on the surface of a solid. An example showing the need in this unit is that of oil clinging to the different internal parts of an engine. In order to understand this principle better a simple demonstration using the unit shown can be performed.

   Using an eyedropper drop small quantities of water, motor oil, and cutting oil on the heating test unit. Use different weights of motor oil with and without additives. Note how the materials react to the heated metal. Some bounce off (water) some spread quickly, some slowly. Those that tend to spread and not bounce off have the better wetting characteristics.

2. Foaming

Foaming takes place when oils become mixed with air. This situation can and does take place in the crankcase of engines. This test is to determine the foaming characteristics of lubricating oils.

This test can be accomplished with a blendor and various brands and weights of motor oils. Also, additives may be used. Pour a quantity of specimen in the blendor and agitate it for a specified time (usually till some or all samples foam). Pour specimen in test tube and let stand for a certain amount of time. Then brands and weights can be measured to see which will come back quickest after foaming.

3. Flash test

The flash point is the lowest temperature at which application of a test flame causes the vapors above the surface of the liquid to ignite. This test is performed on petroleum products and is used to ascertain volatility.

The test cup is filled to a specified level with the sample. The temperature of the sample is increased rapidly at first and then more slowly. At specified intervals a small test flame is passed across the cup. The lowest temperature at which the vapor will ignite is taken as the flash point.

Third Day: Student Experiments (Viscosity & Temp)

Viscosity is a very important characteristic of lubricating oil. Some properties of engine oils that are related to viscosity are: startability at low temperatures, rate of oil consumption, efficiency as a coolant, etc.

The test apparatus should be set up as indicated in the included picture. Fill a beaker 3/4 full with the first sample and check with viscometer and stop watch at room temperature. Then begin heating the sample and recording the temperature at 100, 200, 300 & 400 degrees. Then continue through the spectrum of samples. The results can be compared more easily if the results are tabulated in the form of a graph.

Fourth Day: Student experiments (load test)

To perform this test, construct a tester as shown in the picture. Insert test pin and bearings into the tester and fill the recess around the test pin with the oil to be tested. Then tighten the bolt finger tight. Align the test pin carefully into the test pin holder which is mounted in a drill press. Clamp the tester to the drill press table. Set the drill press for a speed of approximately 600 rpm. Start the drill press and every ten seconds apply more torque to the bolt. Record the torque reading and the pressure. Continue this procedure until the oil breaks down causing the test pin and bearing to seize which in turn will break the test pin. Repeat this procedure with various types and rated oils. Additives can be added also.

Fifth Day:

The fifth day can be used to finish experiments, tie loose ends together, or give a unit exam. If this unit will be followed with other units on petroleum products this day could be left out.

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE:

1. What effect do additives have on the load capacity of oil?
2. Is viscosity related to load capacity?
3. Is a 10-30 superior in all cases?
4. Can 20 weight oil be used as an all purpose oil?
5. Is the flash and fire point the same for some products?
6. What is the difference between the flash and fire points?
7. What causes foaming?
8. Are the wetting characteristics the same for all petroleum products?

UNIT EVALUATION:

1. Subjective examination.
2. Visual examination.
3. Student experiments.
4. Student feedback.

DEFINITION OF TERMS:

1. Foaming: the presence of air bubbles in oil
2. Flash: the point at which application of a test flame causes the vapors above the surface of a liquid to ignite

3. Viscosity: a measure of a liquid's resistance to flow
4. Wetting: the action a liquid takes on the surface of a solid in spreading out and filling and covering the valleys and peaks.

REFERENCES:

STUDENT:

Auto Mechanics Fundamentals, Stockel. Goodheart-Wilcox. 1963.

ASTM Standards, Part 17. American Society for Testing Materials, Philadelphia, Pa.

TEACHER:

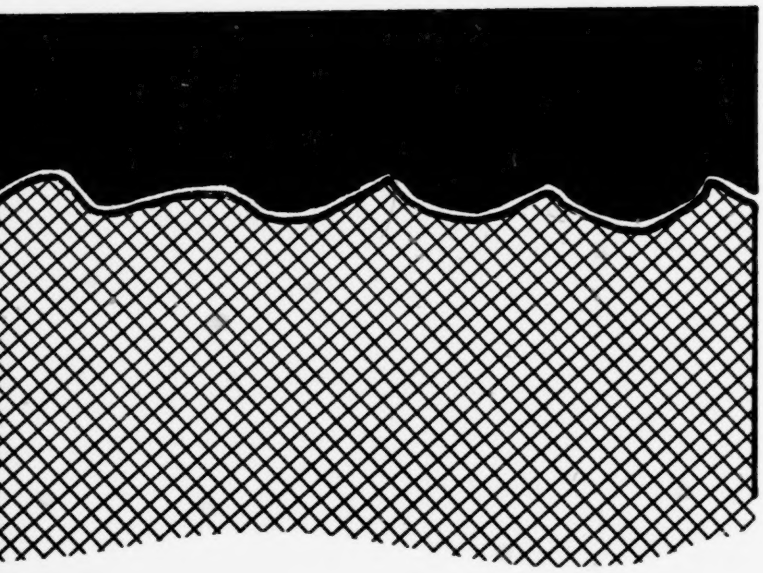
Engineering Materials Handbook, Mantell. McGraw-Hill. 1958.

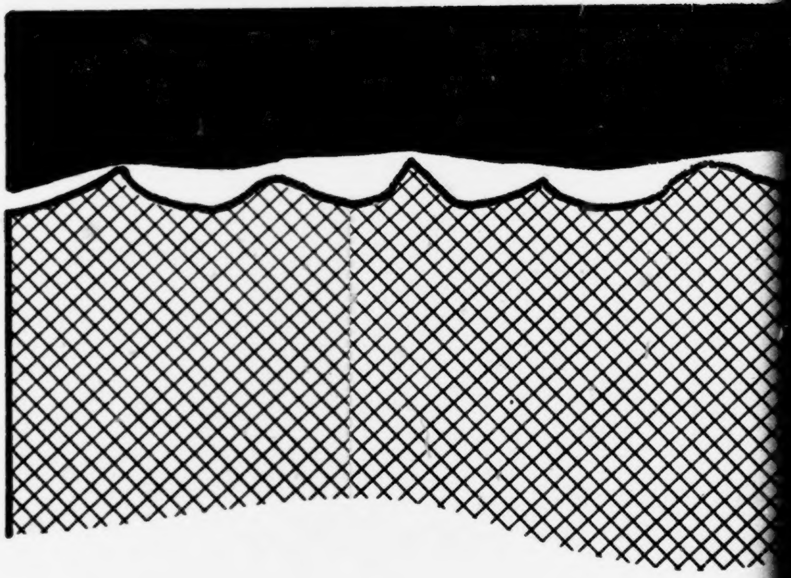
Handbook of Petroleum Asphalt and Natural Gas. Roy CRoss. 1931. Kansas City Testing Lab.

Materials Handbook, Brady. McGraw-Hill. 1956.

500						22	
450			25			20	
400		22	22	22		16	18
350	18	18	18	19		15	17
300	16	16	16	16	12	14	16
250	13	12	12	13	10	12	15
200	10	10	10	11	8	10	14
150	7	7	8	8	4	7	10
100	5	4	5	5	1	5	5
	10	20	30	10-30	STP	30 STP	10-30 STP 2,000

WETTING





SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: L. Wayne Dickerson
Senior High School
Lindsborg, Kansas

INSTRUCTIONAL LEVEL: Jr. High, Sr. High, College

TITLE: Flash & Fire Points of Engine Motor Oils

PRESENTATION TIME:

INTRODUCTION:

Flash point, the temperature at which vapors form a flammable mixture with air, is one indication of the volatility of petroleum products. It is useful in the identification and claasification of products, and is an important control test in refining operations.

Fire point, the temperature at which the vapor will ignite and burn steadily, is now of less importance except in the classification of the heavier petroleum products. To be reproducible and meaningful, flash and fire point tests must be under strictly specified and closely controlled conditions, in specified apparatus of special design.

OBJECTIVES:

1. To show this concept of flash point and fire point in a more meaningful way
2. To show the effects of different temperatures on the lubricating oils and other liquids. (Materials other than lubricating oils may be tested in this manner, i.e. kerosene, asphalt..)
3. To promote interest and motivation toward further study in the lubrication fields.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Power Mechanics

INTER-RELATION WITH OTHER SUBJECTS:

The Metal field could use this unit as well as Vocational Agriculture. Many of the cutting tools operate at fairly high temperatures. The Science classes can use this experiment as a means of breakdown on lubricating oils. The use of this test can clarify friction, expansion, and load bearing characteriatics of fluids. Also for studying corrosion.

USE IN INDUSTRY:

Oil must act as a coolant to assist in carrying away a great deal of heat that is built up by friction. Friction cannot be eliminated so industry is constantly in search of a better means of reducing this friction. This test provides a means of end testing on this lubricating material.

MATERIALS AND EQUIPMENT:

The equipment used in this unit is such that any teacher can build up to run a satisfactory test. A copy of the required equipment is enclosed.

1. Set up of equipment as designated on sketch
2. Samples of various brands of oil
3. Samples of various weights of oil
4. A protective shield to place around equipment during the test
5. A suitable time piece with second hand to record the times
6. Set up should be set up near an exhaust fan

EDUCATIONAL MEDIA:

Film: Refining Oil for Energy, American Oil Co.
Transparencies: Distillation and Fractionization

UTILIZATION IN THE TEACHING LEARNING ENVIRONMENT:

SAFETY:

1. Protecting shield around 3 sides of equipment
2. Exhaust hood with adjustable draft
3. Asbestos card close at hand to extinguish the flames
4. Asbestos gloves to protect the hands
5. Safety glasses

PRESENTATION:

Typical student experimentation or teacher demonstration. However, as in all student experiments, the teacher should first clearly demonstrate the following:
Flash Point:

1. Place the heater, tester and protecting shield on level, steady table, in dim light
2. Using a graduate, and taking care to avoid wetting the cup above the final liquid level, measure 50 ml± 0.5 of the sample into the test cup. Both the graduate and sample should be cooled,

if necessary, so that the sample temperature at the time of measurement is at least 20° F below the expected flash point. It is essential that the sample temperature be maintained at least 20° F below the expected flash point during the transfer from the sample container to the graduate and from the graduate to the test cup. Destroy air bubbles on the surface of the sample. Place the thermometer vertically halfway between the center and edge of the cup and secure it firmly so that the bottom tip is 1/4 inch from the bottom surface of the cup.

3. Light the ignition flame, and adjust it to form a spherical flame matching in size the 5/32 sphere on the apparatus.
4. Apply heat under the test cup, and adjust it so that the temperature of the sample increases at a rate of 2° ± 0.5° F per minute
   NOTE: With heavier materials this rate of heating cannot always be obtained
5. Determine the approximate flash point by passing the taper flame across the sample at intervals of 2° F. The time required to pass the ignition flame across the surface of the sample should be 1 second
   NOTE: If a film should form on top of the sample, it should be distrubed mechanically each time before the taper flame is passed.
6. Record this test and then repeat the procedure by cooling a fresh portion of the sample, the test cup, and thermometer to at least 20° F below the approximate flash point. Resume heating, and pass the taper flame across the sample at two intervals of 5° F and then at intervals of 2°F until the flash point occurs. Record this information and standardize the results using at least three recorded tests, other than the initial test.

Fire Point:

1. Continue the heating so that the sample temperature increases at a rate of 10°F± 1°F per minute.
2. Pass the taper flame over the sample at 5°F intervals, unitl the oil ignites and continues to burn for at least 5 seconds. Record the temperature at this point as the fire point of the oil.

3. Repeat the above test, so as to have three tests other than the initial test and set up as standard.

Observations:

1. Questions to be answered during the experiment:
    - a. What effect will viscosity have on the flash and fire point?
    - b. Why is the volatility of petroleum products important?
2. Areas for Additional Study:
    - a. What is meant by viscosity?
    - b. What other properties of oil are important?
    - c. How might they effect engine performance?

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE:

1. Run flash and fire test
2. Record performances of various grades of oil
3. Hand in results of test for laboratory experiment

UNIT EVALUATION:

1. Check and recheck for weakness in unit
2. Study and improve test equipment
3. Check results of large lubrication test to determine the value of the experimental testing

DEFINITION OF TERMS:

Flash Point: the temperature at which vapors form from lubricating oils mix with air to a point where volatility exists.

Fire Point: the temperature at which the vapor will ignite and burn steadily

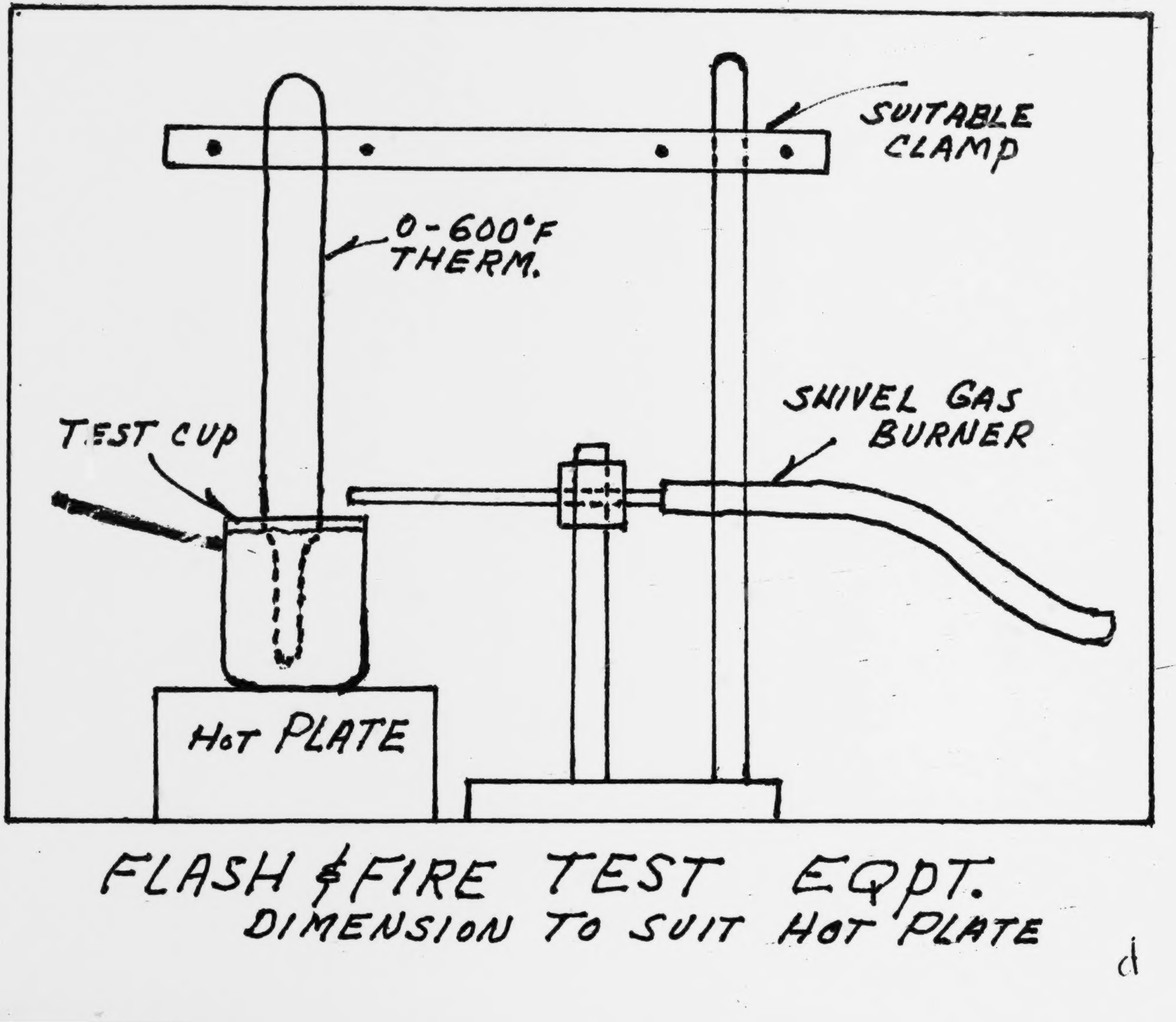
REFERENCES:

STUDENT

1. Refining Oil for Energy - American Oil Co.
2. Fisher/Tag Manual for Inspectors of Petroleum
3. ASTM, Standards, Part 17, 1967

TEACHER

ASTM Standards, Part 17, 1967
Fisher/Tag Manual for Inspectors of Petroleum


SUITABLE CLAMP
0-600°F THERM.
TEST CUP
SWIVEL GAS BURNER
HOT PLATE

FLASH & FIRE TEST EQPT.
DIMENSION TO SUIT HOT PLATE

d

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: Roger L. Barnes
Horace Mann Junior High School
Colorado Springs, Colorado

INSTRUCTIONAL LEVEL: 7th and 8th Grade

TITLE: Fractional Distillation of Crude Oil

PRESENTATION TIME: 30 to 40 minutes

INTRODUCTION:

Refining of petroleum consists basically of separating crude oil into parts or fractions and then treating or changing these fractions as needed to make them into the many different petroleum products. Most of these products such as kerosene, fuel oil, lubricating oil and waxes are fractions of crude petroleum which have been treated to remove undesirable components. Other products have, in addition to being treated, had other things added to them to make them more useful. An example of this is adding soap to lubricating oil to make grease. There is still a third group of products which does not come from crude petroleum as a fraction, but takes the fractions and changes them to create products which are totally or in part synthetic.

Fractional distillation is the first step in this refinement process of crude petroleum. The nature of the fractions obtained from this step depends on the composition of the crude petroleum and on the types of finished products needed. Some crude oils do not contain hydrocarbons which will produce all of the needed products. Some crude oils will have a high percentage of light oil and gas while others will have more lubricating oil and asphalt. Also not all fractions can be obtained at the same time because of the overlap in their boiling range. This makes it evident that obtaining a quality finished product from petroleum is a complex process.

OBJECTIVES:

To give the student information about fractional distillation as used in petroleum refinement.

To make the student aware of the complexity of petroleum and the problems in refining it.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Power Mechanics

INTER-RELATION WITH OTHER SUBJECTS:

Refining petroleum is a question of the chemical and physical handling of it to produce a finished product. So in refining as with the total field of petroleum the sciences are put to practical use. Studying petroleum in this light should offer the student a great deal of reinforcement in his study of science.

In industrial arts, a knowledge of petroleum and petroleum products should help the student to make wiser selections and use of these many products.

USE IN INDUSTRY:

All industries use one or many of the products derived from petroleum. It furnishes fuels to produce power, lubricants for the machinery, and many of the chemicals and products used as raw materials. The relationship of petroleum products and industry is so close that without them nearby, everything would come to a stop. So it can be said that petroleum is one of the base materials of our technological society.

MATERIALS AND EQUIPMENT:

A. Overhead projector
B. Movie projector
C. Slide projector
D. Demonstration Equipment
    1. Distillation tube
    2. 500 ml. flask
    3. two 100 ml beakers
    4. 300 ml. beaker
    5. 300° F. thermometor
    6. Heat source
    7. Solution
        a. 50 ml. alcohol
        b. 50 ml. water
        c. 1 teaspoon salt (NaCl)
        d. Food Color

EDUCATIONAL MEDIA:

A. Set of two transparencies
B. Set of 35mm slides
C. Films (suggested)

1. Refining Oil for Energy
2. Oil - the Invisible Traveler
3. The Story of Oil Marketing
4. Pattern for Chemicals
5. Crude Oil Distillation
   Shell Oil Company
   50 West 50th Street
   New York, New York 10020
6. The Why of Automation Lubrication
7. Lubrication
   U.S. Department of Interior
   Bureau of Mines
   Interior Building
   Washington, D.C. 20240
8. Oil Films in Action
   General Motors Corporation
   Public Relations, Film Library
   Detroit, Michigan 48202

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT:

SAFETY:

In any discussion of petroleum and petroleum products it should be stressed throughout that they can be dangerous materials. For example, most of the materials are flammable and will ignite easily. Many others are highly explosive. Also, with the gaseous materials there is the danger of asphyxiation. This is equally true with carbon monoxide which is the by-product of combustion of hydrocarbon fuels. Therefore, when working with hydrocarbons in most forms it is wise to exercise caution.

PRESENTATION:

1. Simple Distillation
   a. Ancient Origin
   b. First used to make liqueur
   c. Separation of two or more liquids with different boiling points
   d. Complete separation cannot be accomplished in one run.
   e. Redistilling for pure product.
   f. Early refining of crude oil
   g. Shell still
   h. Batch method
   i. Slow and inefficient method

2. Fractional Distillation
    a. First used to make whisky in 1831
    b. Difficult to use with petroleum because of its complexity.
    c. First attempt was a series of simple stills one on top of another.
    d. Bubble tower or fractionating tower
        (1) Series of trays or plates.
        (2) Temperature gradation - hot at bottom; cool at top
        (3) Light gases move up - heavy liquids move down
        (4) Feed can be anywhere up or down the tower
        (5) Reflux
        (6) Bubble caps and wears
        (7) Tapping trays
        (8) Steam distillation
        (9) Vacuum distillation
        (10) Up to fifty thousand barrels a day
    e. Pipe still heater
        (1) As much as a mile of pipe
        (2) Large furnace
        (3) High temperature (750° F.)
        (4) Under pressure
        (5) Vaporizes most but not all of the crude (60% to 70%)
        (6) Will handle 25,000 barrels a day
3. Refining
    a. Gas processing
    b. Reforming
    c. Cracking
    d. Redistilling
    e. Solvent extraction
    f. Solvent dewaxing
    g. Hydrofinishing
    h. Wax crystallization
    i. Asphalt processing

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE:

1. Quiz
    a. What is the reason for having a fractionating tower?
    b. What makes it possible to separate crude oil into parts?

   - c. What does a pipe still do?
   - d. Does automobile gasoline come from the fractionating tower?
   - e. Define distillation.
2. Observation of student response to presentation of the unit.
3. Observation of student response to the demonstrations.

UNIT EVALUATION:

1. Item analysis of the quiz.
2. Student response and interest in the unit and demonstration.
3. Questions raised by the students.

DEFINITION OF TERMS:

1. Petroleum - the oil that is obtained from the earth.
2. Hydrocarbon - a compound made up of hydrogen and carbon.
3. Organic - a substance which is living or was once alive.
4. Volatility - the ability or tendency to turn to vapor (boil).
5. Distill - to obtain by evaporation and condensation.
6. Fraction - part of the whole.
7. Refine - to make better.
8. Cracking - the process of taking large hydrocarbons such as fuel oil and breaking and reforming them into more useful molecules such as gasoline.
9. Vaporize - to change into a vapor or gas.

REFERENCES:

STUDENT:

1. The Story of Gasoline, Ethyl Corporation
2. Oil for the World, Schackne and Drake

TEACHER:

1. Hydrocarbons from Petroleum, Rossini, Mair and Streff
2. Petroleum Processing, Hengstebeck
3. When the Oil Wells Run Dry, Fuchs
4. Petroleum from Prehistoric to Petrochemical, Purdy

DISTILLATION DEMONSTRATION

Introduction:

The purpose of this demonstration is to show the student how liquids with different boiling points can be separated by distillation. The apparatus needed for simple distillation is available in most chemistry departments or can be obtained from a chemical supply house. Setting up and demonstrating distillation is quite easy and it gives the student a visual concept which can help make clear the more complex process of fractional distillation as used in petroleum refining.

Set-up:

A. Set up a flask with a thermometer which extends near to, but not touching, the bottom of the flask and a tube to connect the condenser tube unit.

B. Set the condenser unit so that it is inclined downward. The vapors can then enter the top and the condensed liquid can be collected at the bottom.

C. Hook up running water to the bottom connection of the condenser unit and drain off at the top connection. This will provide a circulation in the unit needed for cooling.

D. A beaker is placed at the bottom of the condenser unit as a receiver to collect the condensed liquid.

E. A heat source is needed such as a bunsen burner or a propane torch with which to boil the solution.

F. Make sure that all connections are good and tight

Procedure:

A. Mix a solution of about 50 ml. water and 50 ml. alcohol. Add to this solution one teaspoon of table salt and a few drops of food color.

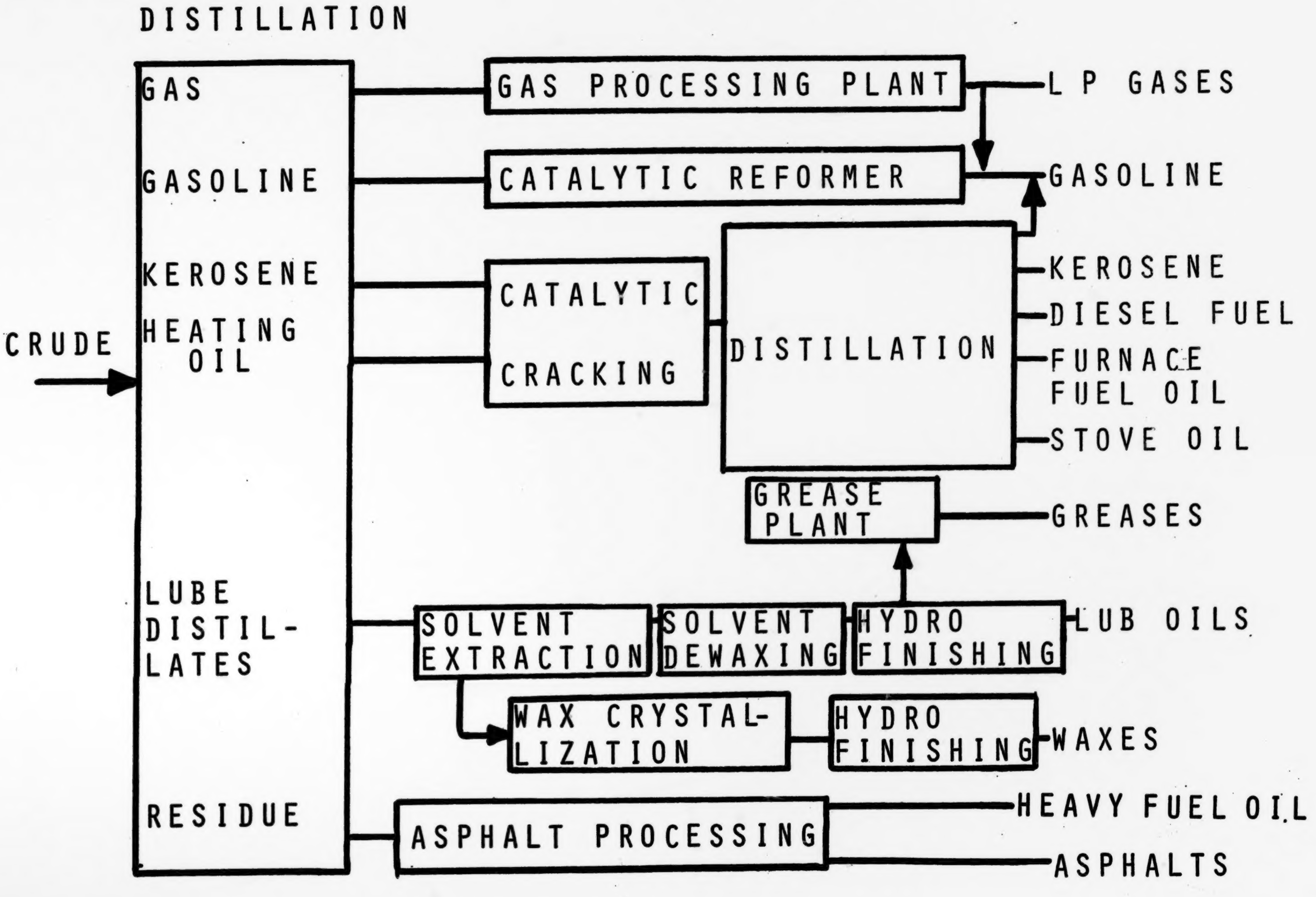
B. Put the solution in the flask and heat to a temperature of 175° to 180° F. At this point, the alcohol will start to boil off.

C. When the alcohol is removed from the solution, change the receiver and raise the temperature to boil off the water.

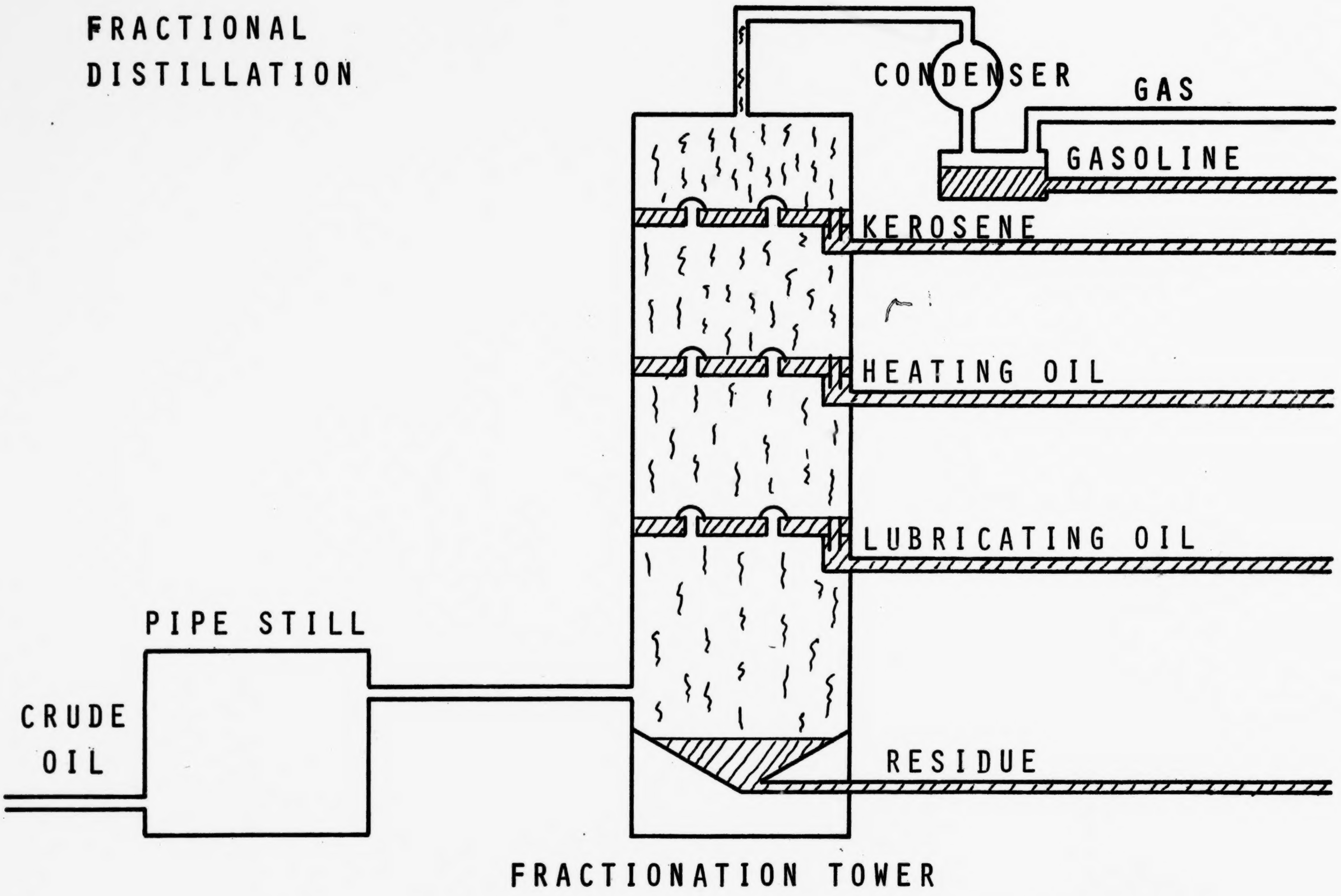
Results:

From this demonstration, the student should be able to see that from the colored solution a clear liquid was distilled, which is alcohol. Then a second clear liquid was obtained, which is the water, and a residue of salt and color was left behind. This process can then be compared to the fractional distillation of crude petroleum.

SIMPLIFIED FLOW THROUGH A REFINERY


DISTILLATION
GAS
GASOLINE
KEROSENE
HEATING OIL
LUBE DISTILLATES
RESIDUE
CRUDE
GAS PROCESSING PLANT
CATALYTIC REFORMER
CATALYTIC CRACKING
DISTILLATION
GREASE PLANT
SOLVENT EXTRACTION
SOLVENT DEWAXING
HYDRO FINISHING
WAX CRYSTALLIZATION
HYDRO FINISHING
ASPHALT PROCESSING
L P GASES
GASOLINE
KEROSENE
DIESEL FUEL
FURNACE FUEL OIL
STOVE OIL
GREASES
LUB OILS
WAXES
HEAVY FUEL OIL
ASPHALTS

FRACTIONAL DISTILLATION


CONDENSER
GAS
GASOLINE
KEROSENE
HEATING OIL
LUBRICATING OIL
RESIDUE
CRUDE OIL
PIPE STILL
FRACTIONATION TOWER

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: Roger L. Barnes
Horace Mann Junior High School
Colorado Springs, Colorado

INSTRUCTIONAL LEVEL: 7th and 8th grades

TITLE: Obtaining Crude Petroleum

PRESENTATION TIME: 10 to 15 minutes

INTRODUCTION:

The origin of petroleum we know dates back millions of years, but exactly how it was formed is a question which science has been unable to answer. However, the process by which petroleum was formed must have been a common one and the materials from which it was made equally common because petroleum occurs widely throughout the earth's crust. In fact, the volume already recovered makes petroleum the second most plentiful liquid in the world.

Research that has been done on the occurrence of petroleum seems to indicate a connection between organic tissue, probably plants and animals, and the sea. Almost all petroleum is found in rock of marine origin. It is thought that the accumulation of organic matter in the sediment at the bottom of the sea was the start of the process. Then over millions of years the fats, oils, and waxes were transformed to petroleum by heat, pressure and bacterial action.

Whatever the origin of petroleum the important question today is the location and recovery of this rich natural material.

OBJECTIVES:

To give the student information as to the origin, location, and recovery of crude petroleum.

To impress upon the student the importance of petroleum as a natural raw material.

INTER-RELATION WITH OTHER SUBJECTS:

A. UNIT SUBJECT AREA: Power Mechanics

B. INTER-RELATION WITH OTHER SUBJECTS:

This unit has its strongest relationship to the science of geology since we are dealing with a raw material which is obtained from the earth's crust. Of course a relationship could also be established with the other sciences and math.

In industrial arts this unit could be used in several areas as related information dealing with the source of many of the materials used. Not only fuels and lubricants but with the many synthetic materials obtained from petroleum.

USE IN INDUSTRY:

All industries use one or many of the products derived from petroleum. It furnishes fuels to produce power, lubricants for the machinery, and many of the chemicals and products used as raw materials. The relationship of petroleum products and industry is so close that without them nearby, everything would come to a stop. So it can be said that petroleum is one of the base materials of our technological society.

MATERIALS AND EQUIPMENT:

A. Overhead projector
B. Movie projector
C. Slide projector

EDUCATIONAL MEDIA

A. One overhead trnasparency (enclosure)
B. Set of 35mm slides
C. Films (suggested)
    1. Prospecting for Petroleum
    2. Birth of an Oil Field
    3. 10,000 Feet Deep
    4. Pipeline
       Shell Oil Co.
       50 West 50th Street
       New York, New York 10020
    5. Fill 'er Up
       Dupont
       Motion Picture Distributor
       1907 Market Street
       Wilmington, Delaware 19898
    6. The Story of Gasoline
       Art Film Labs Inc.
       245 West 55th Street
       New York, New York 10019

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT:

SAFETY:

In any discussion of petroleum and petroleum products, it should be stressed throughout that they can be dangerous materials. For example, most of the materials are flammable and will ignite easily. Many others are highly explosive. Also, with the gaseous materials there is the danger of asphyxiation. This is equally true with carbon monoxide which is the by-product of combustion of hydrocarbon fuels. Therefore, when working with hydrocarbons in most forms, it is wise to exercise caution.

PRESENTATION:

1. Accumulation of petroleum
    a. Source rock
        (1) Fine-grained and impervious
        (2) Shale and limestone
        (3) Drilling source rock rarely produces petroleum in any quantity
    b. Reservoir rock
        (1) Porous limestone and sandstone
        (2) Void spaces
        (3) Porosity and permeability
        (4) Oil Pools
    c. Traps
        (1) Anticline
        (2) Salt dome
        (3) Fault trap
        (4) Stratigraphic
        (5) Cap rock
2. Locating Oil fields
    a. Early discovery wells
        (1) Oil and gas seepage
        (2) Salt wells
        (3) Located by chance
    b. Modern petroleum geology
        (1) Locating promising formations
        (2) No guarantee of oil
        (3) Seismic Survey
        (4) Gravitymeter survey
        (5) Magnetometer survey
3. **Drilling and Petroleum**
    a. Cable tool drilling
        (1) Developed in China centuries ago
        (2) 20 to 150 feet of hole per day
        (3) Used down to 2000 feet but can go 8000 feet or more

(4) Walking beam
(5) String of tools
(6) Bailer
(7) Two man rig

b. Rotary Drilling
  (1) Developed 1900
  (2) First well 1901
  (3) Ten times faster than cable
  (4) 100 to 300 feet per day
  (5) Wells to 20,000 feet or more
  (6) Drill stem
  (7) Drill bits
  (8) Rotary table
  (9) Slush pump

c. Marine Drilling
  (1) Sunken barge - 20 feet deep or less
  (2) Pile support up to 70 feet depth
  (3) One well in Gulf 32 miles off shore

d. Well Completion
  (1) Drill stem test
  (2) Explosive fracturing
  (3) Hydraulic fracturing
  (4) Gun perforator

4. Oil Production
  a. Gas-cap drive
  b. Dissolved-gas drive
  c. Water drive
  d. Artificial lift
  e. Oil, gas, and water separation

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE

1. Quiz
  a. Is oil found where it is formed?
  b. What is an oil pool?
  c. Describe two types of trap structures.
  d. What is a cap rock and what does it do?
  e. How were the first oil wells discovered?
  f. Can a geologist locate oil?
  g. What is the most widely used method of drilling oil wells?
  h. How deep do oil wells go into the earth?
  i. What has to be done after a well is drilled before production starts?
  j. How is oil obtained from the well?

2. Observation of student response to presentation of the unit.

UNIT EVALUATION:

1. Item analysis of the quiz.
2. Student response and interest in the unit.
3. Questions raised by the students

DEFINITIONS OF TERMS:

1. Petroleum - The oil that is obtained from the earth.
2. Hydrocarbon - A compound made up of hydrogen and carbon.
3. Organic - A substance which is living or was once alive.
4. Geology - The science of the earth's structure.
5. Porosity - Having holes or voids through which liquid or air can move.
6. Permeability - To penetrate or move through a substance.
7. Stratification - To form in layers as the rock in the earth's crust.
8. Anticline - A bulge in the rock layers of the earth's crust.
9. Fault - A break in the rock layers of the earth's crust.
10. Seismic - A vibration of the earth's crust such as an earthquake.

REFERENCES:

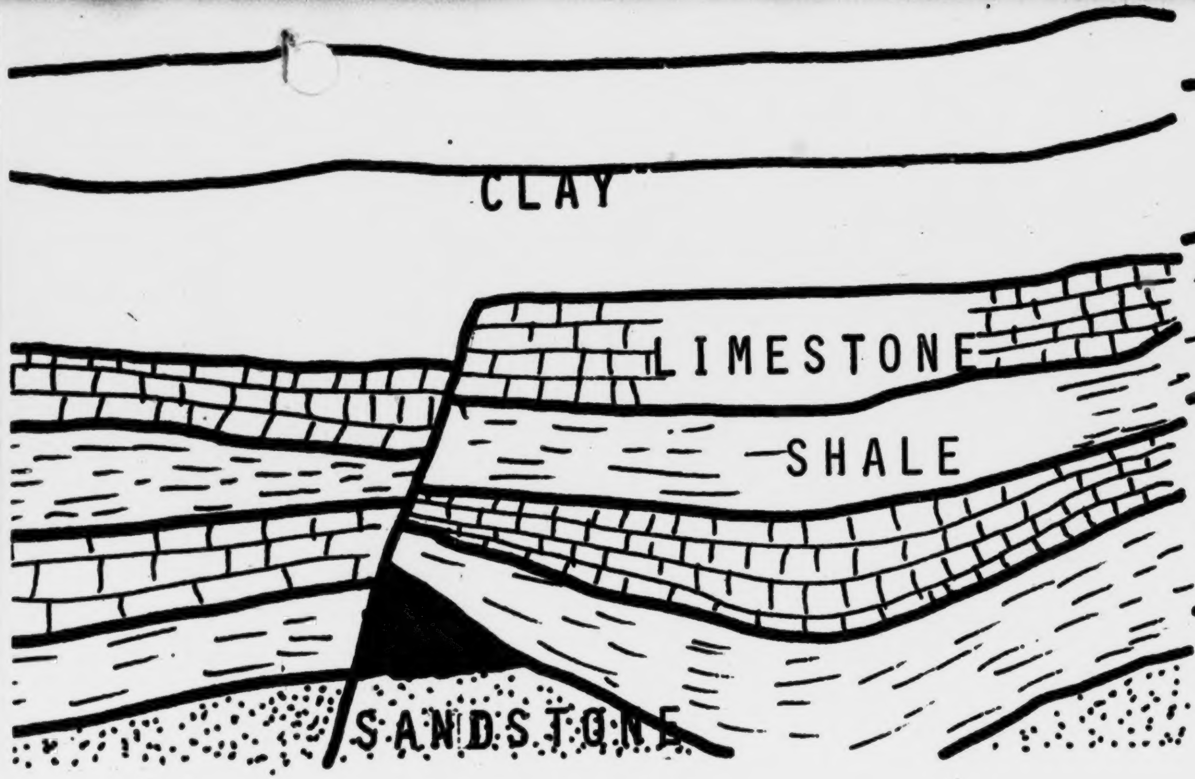
STUDENT:

Oil for the World, Schackne and Drake

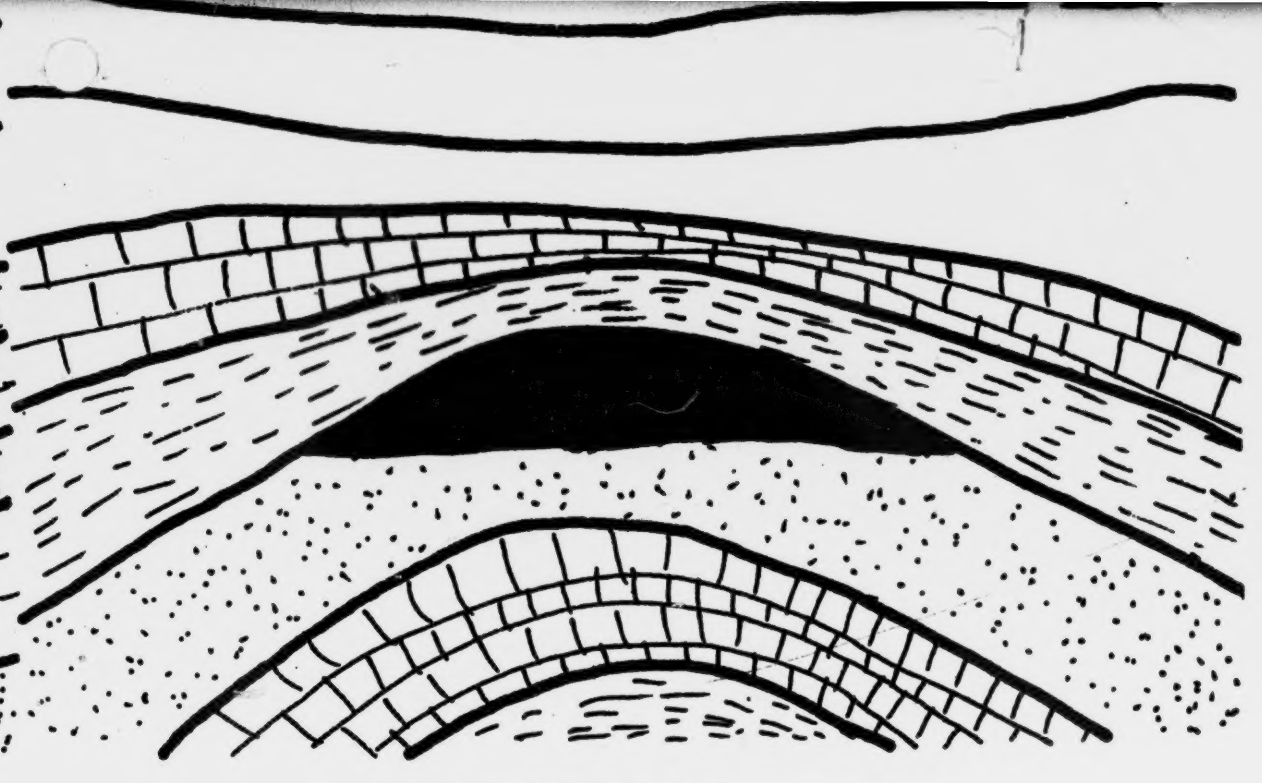
TEACHER:

1. Hydrocarbons from Petroleum, Rossini, Marr and Streiff
2. Petroleum Processing, Hengstebeck
3. When the Oil Wells Run Dry, Fuchs
4. Petroleum from Prehistoric to Petrochemical, Purdy

GEOLOGIC OIL TRAPS


CLAY
LIMESTONE
SHALE
SANDSTONE

FAULT



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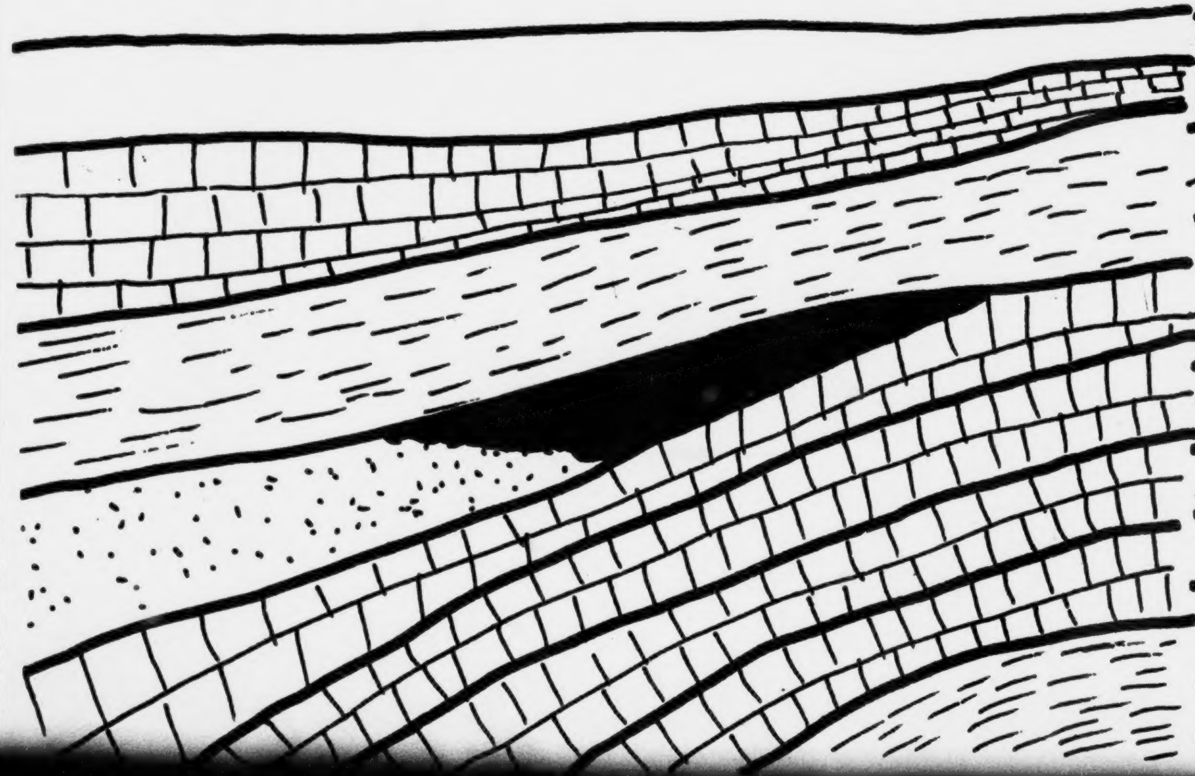
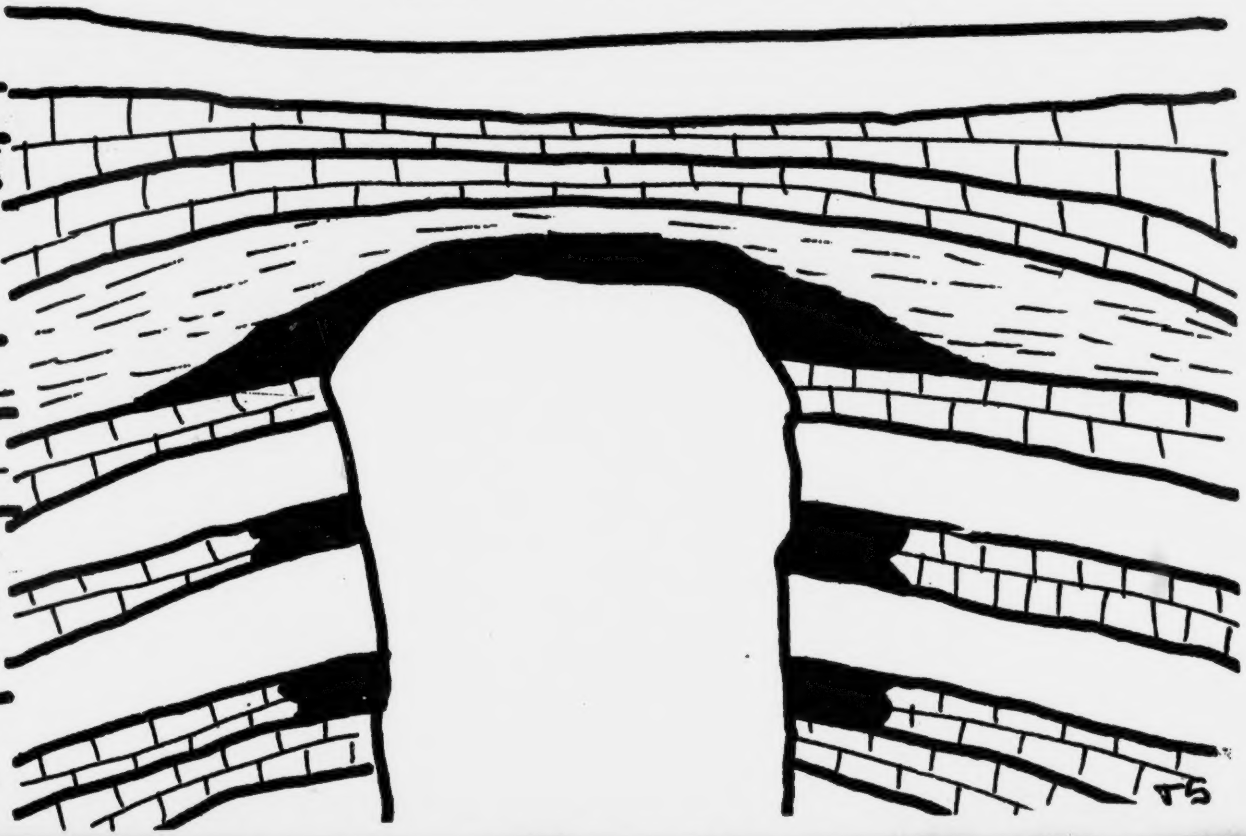


SALT DOME



SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: L. Wayne Dickerson
Senior High School
Lindsborg, Kansas

INSTRUCTIONAL LEVEL: Jr. High - Sr. High - College

TITLE: Oil-Grease Lubrication Principles

PRESENTATION TIME: 1 1/2 hours

INTRODUCTION:

Lubrication greases are described by A.S.T.M. (American Society Testing Materials) as: " A Combination of a petroleum product and a soap or a mixture of soaps, suitable for certain types of lubrication." A lubrication grease is therefore a soap-thickened oil, its use being a substitute for lube oil in locations where unsatisfactory oil retention makes the use of grease more desirable as a means of reducing friction and wear. Greases also act as coolants, sealants, and a means of keeping bearing surfaces clean.

OBJECTIVES:

1. To learn how greases are made
2. To learn the types and principle characteristics of oil greases
3. To learn the methods of oil-grease lubrication
4. To perform some of the many materials tests on lubricating greases
5. To learn the method by which greases are classified

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Power Mechanics

INTER-RELATION WITH OTHER SUBJECTS:

Other Industrial Arts subjects which may use this unit are: Woods, Metals, Graphic Arts and Vocational Agriculture. The Physics and Chemistry departments may also find some value in this unit for their subjects.

USE IN INDUSTRY:

Lubrication problems will be with Industry as long as manufacturing exists. Vast amounts are spent each year to study the many old types and new types of lubricants for the vast improvements on modern day machines.

MATERIALS AND EQUIPMENT:

1. Samples of oil and greases
2. Beaker for use in class viscosity showing (water)
3. Equipment for grease making:
    a. Ivory soap
    b. 250 ml beaker (2-3)
    c. Electric or gas hot plate to heat materials
    d. Filter cloth
    e. 30 ml of 1 molar lithium chloride solution
    f. Small amounts of powdered zinc, powdered aluminum, collodial graphite, molybdenum sulfide powder
    g. A clean dry roller bearing and a clean dry ball bearing

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT:

PRESENTATION:

I. How Greases are made:
    A. Chemical Compounds
        1. Lubrication grease is a combination of a petroleum product and a soap or a mixture of soaps
            a. Soap Compound Structure (saponification)
            b. Bases
            c. Oils
    B. Greases of soap thickened oil type are of two types:
        1. The cooked or boiled type - autoclave
        2. The cold type - cold sett - temp. less than 150° F
            a. Differences in manufacture are differences in:
                (1) temperature
                (2) method of arriving at saponification
            b. Differences in characteristics and quality are quite marked
            c. Newer type called "continuous process"
                (1) not yet proven for all equipment
                (2) based on stedy mixing process

            NOTE: SAMPLES OF VARIOUS TYPES OF GREASES SHOWN AT THIS TIME.

II. Types of Grease Manufactured and Characteristics:

- A. Lime Base - smooth buttery texture, relatively low melting point, and resistance to moisture. Cannot be used above approximately 175° F. because of physical and chemical breakdown.
- B. Soda Base - stringy texture, because of which they are referred to as fiber or sponge grease. They are not resistant to moisture but may be used above 175° F.
- C. Aluminum Base - transparency type grease. Smooth, buttery and with a high melting point; excellent for pressure greases and for centralized lubricating systems.
- D. Lithium Base - newer type, not too widely produced. Production and cost difficulties at present. Good water resistance, high melting point, good stability, extremely good temperature consistency characteristics.
- E. Lead Base - not too widely used today, only as a mixed base grease. It is sometimes called extreme pressure grease.

III. Tests for Uniformity and Quality:

- A. Greases are classified by consistency tests.
  - 1. Permits selection of a grease of the correct grade for a specific application.
  - 2. Consistency tests now use numbers as means of identification grades.
    - a. Early days, each company used their own system - numbers, letters, names, etc.
    - b. National Lubricating Grease Institute (NLGI) set up seven standard grades by the ASTM penetration at 77° F to serve the whole industry.

NOTE: NLGI TRANSPARENCIES - 0 - L #1

NLGI	ASTM penetration at 77°F
No. 0	355-385
No. 1	310-340
No. 2	265-295
No. 3	220-220
No. 4	175-205
No. 5	130-160
No. 6	85-115

- c. Other greases, lighter or heavier, produced by the companies now carry their own numbers or letters systems. Basically special purpose type greases.

- B. Physical Tests
  1. Consistency
  2. Melting point at degrees F
  3. Bleeding out of oil molecules
  4. Water content (vaporization)
  5. Color
  6. Texture
  7. Water absorption
- C. Chemical Tests:
  1. Stability (oxidation)
  2. Ash
  3. Composition (% of components)
  4. Free alkali or acid
  5. Corrosion
- D. Mechanical Tests:
  1. Pressure
  2. Dropping point of lube greases
  3. Corrosion test for solidity
  4. Consistency of lube greases and petrolatium

IV. Methods of Lubrication:

- A. Grease:
  1. Compression cups
  2. Tunnel cups
  3. Wells
  4. Packed bearing
  5. Pressure gun
  6. Central pressure system
- B. Oils:
  1. Hand
  2. Waste packed or Pad packed
  3. Wick-fed
  4. Drop-sight-feed
  5. Bottle
  6. Ring, chain, or collar
  7. Mechanical Pressure Feed
  8. Oil bath
  9. Splash & Splash Circulating System
  10. Gravity Circulation
  11. Pressure Circulation (force-feed)

V. Oils and Greases for further study:

- A. Steam Engine and Turbine Oils
- B. Pneumatic Machine Oils and Greases

C. Pump Oils and Greases
D. Railroad Lubricants
E. Gas, Hydraulic and Steam Turbine Lubes
F. Clay Products Lubricating Oils
G. Cutting or Machining Fluids
H. Heat Treating Fluids
I. Hydraulic Systems Fluids

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE:

1. Some materials process tests will be performed at end of unit
   a. Consistency & Melting & Bleeding Test
   b. Color
   c. Water Content
2. Large unit test

UNIT EVALUATION:

1. Check and recheck for weaknesses
2. Large unit test
3. Changes evident for further teaching of unit

DEFINITION OF TERMS:

1. Consistency: a condition of holding together; firmness or thickness, amount or degree of thickness as of a liquid.
2. Petrolatium: a greasy, jellylike substance consisting of a mixture of semisolid hydrocarbons obtained from petroleum.
3. Saponification: the chemical conversion of fats into soap.
4. Cohesion: the act or condition of cohering; tendency to stick together; the force by which the molecules of a substance are held together.
5. Adhesion: the force that holds together the unlike moldcules of substances whose surfaces are in contact; a sticking condition.
6. Bleeding Out: the act of separating; the molecules separate, as in greases, the oil rests on top with the fibre structure at bottom.
7. Compression Cup: a small grease reservoir directly connected to the bearing, with provisions made for exerting pressure on the grease to force it from the reservoir to the bearing.

8. Funnel Cup: a small cup filled with grease has a pin extending from the top through the grease to the shaft. As the shaft turns it heats the pin and the vibration it effects causes the grease to liquify and run into the bearing.
9. Packed Bearing: are antifriction bearings enclosed in grease tight housings which can be lubricated by grease placed in the housing at the time of assembly of the bearing unit. Some have provisions for adding grease when needed. The bearings can usually be operated for a long period of time without attention.
10. Central Pressure System: a pressure gun idea attached to a central reservoir feeding grease through fairly complicated metering systems and lines to the various points to be lubricated on a machine. One push or trigger lubricates all points at the same time with a predetermined amount of grease at the proper time.
11. Wells: Lubrication of a high temperature bearing by the use of a hard grease in the form of blocks, resting upon, or being pressed against, the rotating journal through an open well in the upper half of the bearing, or the lower half exposed journal. The heat meets the grease & carries the soft thin layer around the journal and bearing.

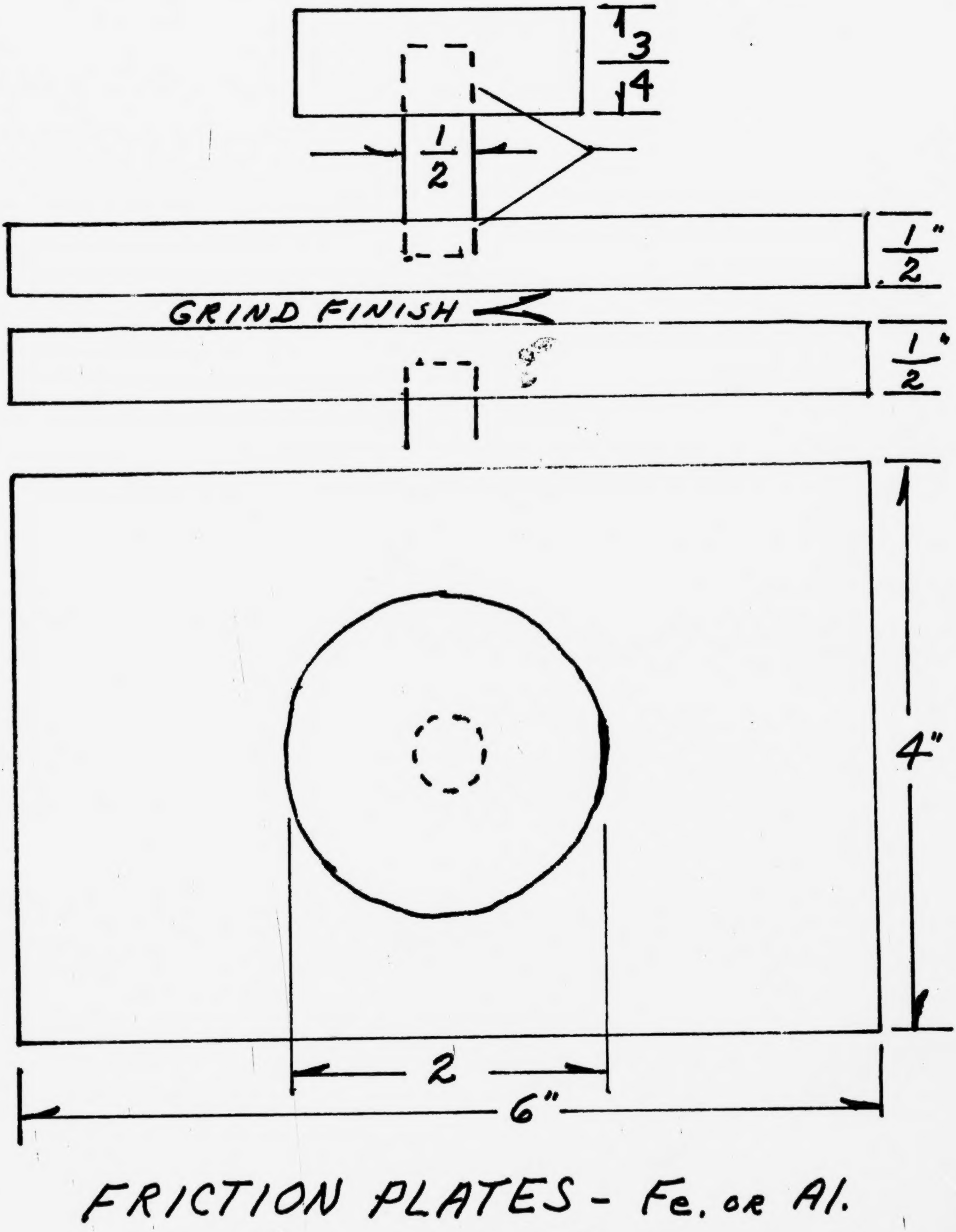
REFERENCES:

STUDENT:

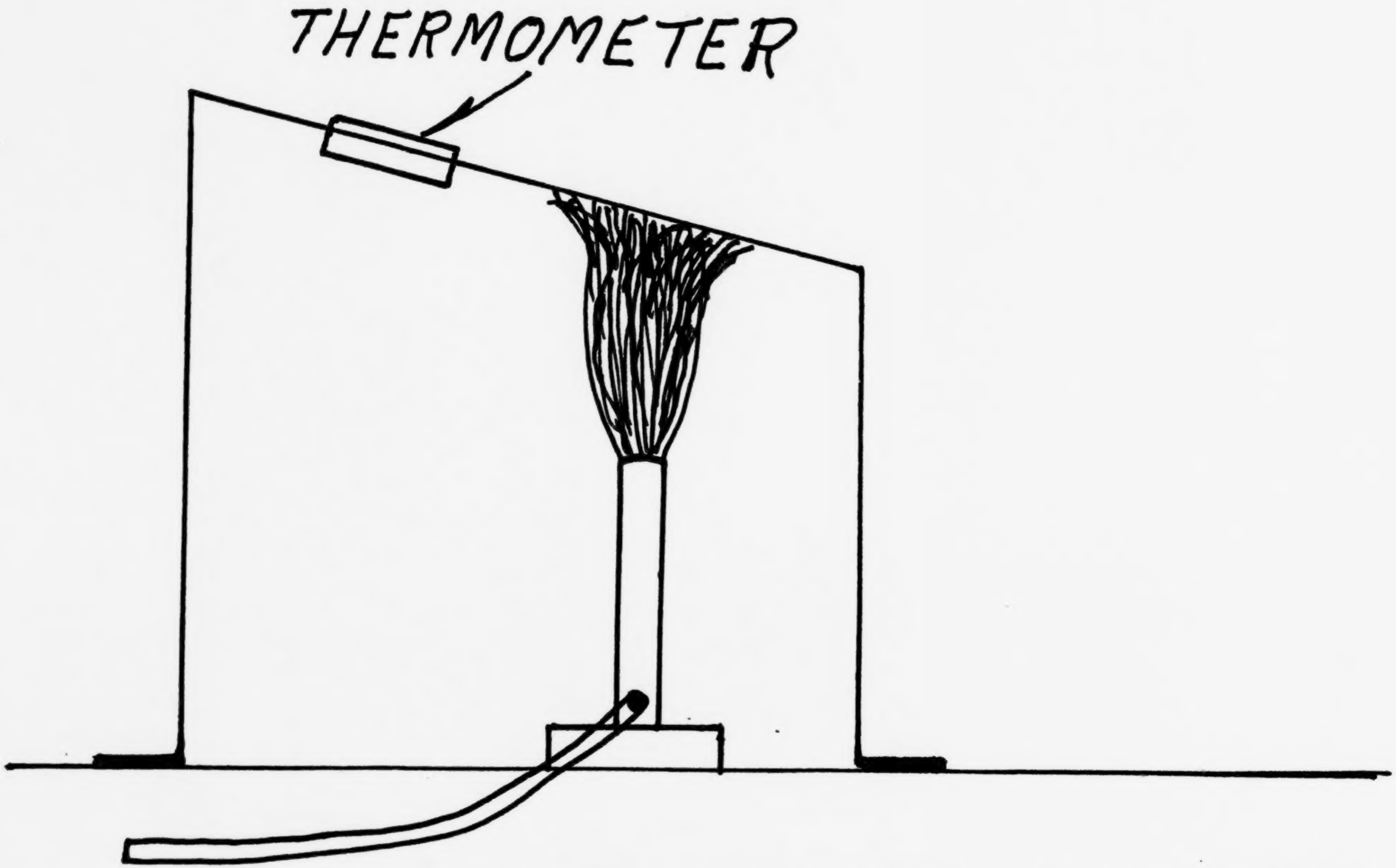
Film - Refining Oil for Energy, American Oil Co.
Stockel, Martin W. - Auto Mechanical Fundamentals, Homewood, Ill. - Goodheart-Willcox Co., Inc. 1963, Ch. 5-1.

TEACHER:

A.S.T.M. Standards, Part 17, 1967
Kock, G.P., PhD. - Handbook of Shell Products, San Francisco, Calif. Shell Oil Co., 1938 - Lubrication section.
Popovitch, M., Fuels and Fundamentals, New York, John Wiley and Sons, Inc. 1959, Chapter 10.


3/4
1/2
1/2"
GRIND FINISH
1/2"
4"
2
6"

FRICTION PLATES - Fe. or Al.
HAND KNOB TO SUIT

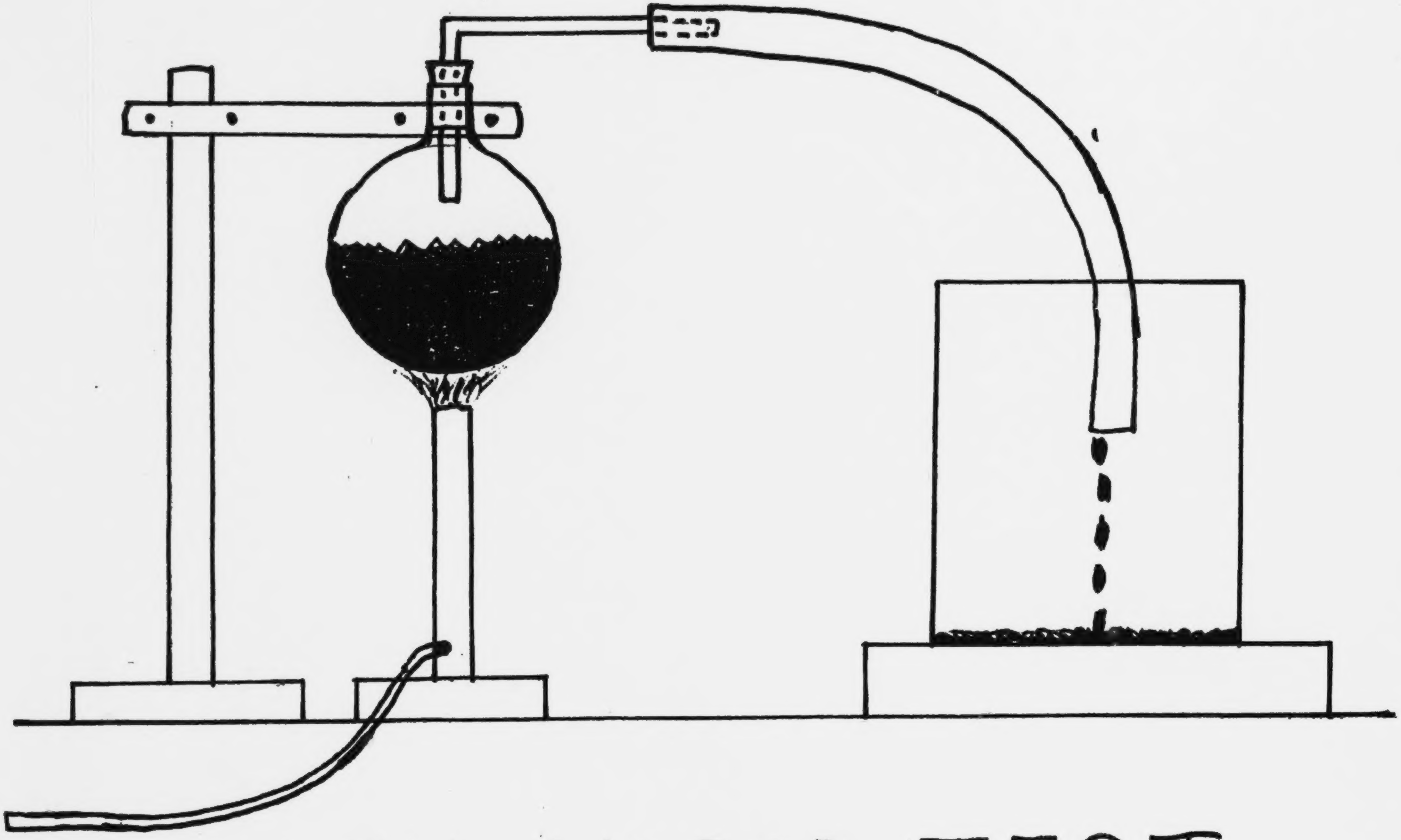

THERMOMETER

MELTING-BLEED
TEST

N.L.G.I. - STANDARD GRADES

N.L.G.I	ASTM-Penetration At 77°F
No. 0	355 - - 385
No. 1	310 - - 340
No. 2	265 - - 295
No. 3	220 - - 250
No. 4	175 - - 205
No. 5	130 - - 160
No. 6	85 - - 115

LIGHTER & DARKER GRADES CARRY THE COMPANIES OWN NUMBER SYSTEM



OIL VAPOR TEST

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: Wayne Dickerson
Senior High School
Lindsborg, Kansas

INSTRUCTIONAL LEVEL: Jr. High - Sr. High - College

TITLE: Overview of Synthetic Lubricants

PRESENTATION TIME: 1 1/2 to 2 hours

INTRODUCTION:

The field of synthetic lubricants has expanded greatly in recent years and more research is underway for the future. Only recently has the government and industry seen fit to release information concerning this research. Information being somewhat of a premium, this unit attempts to list and describe nine basic types of synthetic resins.

OBJECTIVES:

1. To show the advantages of synthetic lubricants over the natural hydrocarbon lubricants.
2. To show how the synthetics improve lubricity over extremely wide temperature ranges, the high thermal and oxidative stability and outstanding resistance to nuclear radiation.
3. To point out how the physical or performance properties can be altered by chemical modification or the incorporation of suitable additives, i.e., solubility characteristics.
4. To point out how additives improve the performance properties of lubes.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Power Mechanics

INTER-RELATION WITH OTHER SUBJECTS:
1. Fluid power courses could use this information.
2. Vocational agriculture
3. Chemistry and Physics

USE IN INDUSTRY:

The government was the first to really show interest; then as information was released, industry as a whole took great interest and did more experimenting, and much more will be done in the future. This is relatively a new field.

MATERIALS AND EQUIPMENT:

Various samples of synthetic lubes.
Samples of various hydraulic fluids.
Some chemical analysis charts are available from oil companies.

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT:

SAFETY:

As this unit is more of an overview with more of a lecture set-up, safety does not apply to this unit.

PRESENTATION:

I. Historical Review
  A. Additives
    1. Since 1910 increased interest in compounding of mineral oils
    2. Early day additives were nearly all by-products of petrol or other low cost raw materials. Now use better refined products and include synthetic organic compounds.
  B. Inhibitors of Oxidation
    1. Antioxidants, their probably mode of action and their importance in organic chemistry were first described in 1922.
    2. Phenols and aromatic amines, products showing pronounced oxidation inhibiting properties while antioxidants only delay the oxidation.
  C. "Boundry lubricants"
    1. Cause a decrease in friction and wear and increase load bearing capacity of bearing.
    2. Monolayer theory of Langmuir
    3. "Active Chlorine" produces protective film of metal chlorides and compounds containing sulphur and chlorine the boundry film formed on gear teeth is ferrous chloride.
    4. Iron phosphide creates polishing effect on bearings. TCP = this reacts with steel to form thin, solid, non-conducting films.
    5. Liquids must excell in wetting ability
  D. Pour point depressants
    1. Synthetics found to be best and most efficient
    2. "Paraflow" first and most effective
    3. "Acryloid" W.W. II innovation - polymers of methacrylic acid esters of higher alcohol
    4. Reduces crystal sizes and reduces interlocking network of interparticle adhesion.

- E. "Viscosity Index Improvers"
    - 1. First were collodial metallic soaps added to oils - linear polymers most effective, however, some linear polymers are not good VI improvers.
- F. Rust Inhibitors
    - 1. Rust inhibition in oils is caused primarily by the physical adsorption on the surfaces of ferrous metals of polar - non-polar molecules of high molecular weight.
    - 2. Failure of rust inhibited oil results form either
        - a. the depletion or desorption of the hydrophobic monolayer as the result of the washing action of the water contacting it.
        - b. the decrease in the average lifetime of adsorption of the polar molecules with increasing temperature.
    - 3. Material obtained from soaps and sulfonates.
- G. "Oil Detergents"
    - 1. Cleans oil
    - 2. Oils contain 2-4% inhibitors and detergents are heavy duty oils - now up 20% most of which is detergents.

II. Rise of synthetic lubricants

- A. Why develop synthetics?
    - 1. Research revealed about chemical constituents of petroleum oils and about methods of refining and selecting those ingredients most wanted.
    - 2. Increasing shortages of suitable petroleum supplies becoming evident in countries like Germany, France and Japan.
    - 3. Growing needs were created by invention or widespread adoption of machines requiring even greater temperature ranges.
    - 4. Various new nonhydrocarbon liquids, which had been synthesized for various reasons, were discovered to have extreme properties of great interest in lubrication
- B. Synthetic Hydrocarbons
    - 1. Large differences in the bulk properties of petroleum fractions having comparable boiling points showed a need to explore more.
        - a. Branched paraffins, cycloparaffins, and aromatic hydrocarbons were found.
        - b. Not yet able to identify all the components in lubricating oils
        - c. Reasonable accuracy now in identifying compositions.
    - 2. Physical Structure Studied

- a. Increasing the length of the aliphatic chain increases viscosity, raises the viscosity, raises the freezing point and the viscosity index and lowers the A.S.T.M. slope.
- b. Side chains also active, increases viscosity, lowers freezing point, decreases V.I. and raises A.S.T.M. slope.
- c. Branched attachments exert a complex influence on the viscosity and V.I.
- d. A branch near the middle is more effective in lowering freezing point.
- e. Cyclic group additions causes larger increases in viscosity and decreases the V.I. more than do alkyl substituents.
- f. Increasing the ratio of the cross section of the molecule to its length decreases the V.I. and raises the A.S.T.M. slope.

3. Mixtures Studied
    - a. Ingredients are more or less random mixtures of hydrocarbons and hydrocarbon derivatives and the known mixtures are not the best.
    - b. Polymerization process using aluminum chloride as the catalyst was the landmark in the history of synthetic lubricants.
    - c. Cost was factor in dropping this plan.
4. Synthetic approaches most used and studied.
    - a. Noncatalytic polymerization of hydrocarbons by electrical discharge methods.
    - b. Catalytic polymerization with aluminum chloride
    - c. Dechlorination of chlorinated hydrocarbons
    - d. Condensation of Olefins with aromatic hydrocarbons.
    - e. Condensation of chlorinated hydrocarbons with aromatics
    - f. Nuclear power plant needs have turned our attention to aromatic polycyclic compounds for a better type of synthetic lubes.

C. Liquid Silicone POlymers

1. Element is easily and cheaply isolated.
2. 28% of earth's crust
3. Chemical behavior is of interest to both organic and inorganic chemists.
4. Electropositive in nature and has some properties of metals. It is tetra-covalent and can attain a maximum of 6 with atoms of fluorine and oxygen.
5. Silicone liquids are linear polymers of the organosiloxane family.

6. Numerous other studies and tests have been run on this type of polymers.
7. The materials cannot function as good boundry lubricants.
8. Solubility is the big problem facing silicones as additives.

D. Liquid POlyorgalkylenes
   1. The solid polymers are water soluble while the polypropylene glycols are oil soluble.
   2. Useful in lubricating oils and hydraulic fluids.
   3. Has self-detergent quality.
   4. Production in America is second only to the ester lubricants.

E. Ester Lubricants
   1. Trimethylomethane reacted with various fractions of mixed fatty acids.
   2. Adipic acid reacted with various fractions of mixed branched alcohols.
   3. An ester of adipic acid and branched nonyl alcohols.
   4. Esters of methyladipic acid and mixtures of branched alcohols.
   5. Commercial quantities of esters are produced from above
   6. Excellent lubricating qualities are due to adsorption properties at the solid oil interface.
   7. The ester gorup prepared and used from 1944 are
      a. Branch - chain alcohols with 3 to 17 carbon atoms.
      b. Branch - chain acids with heramethylene glycol or decamethylene glycol.
      c. Branch - chain acids with triethylene glycol or polyoxyethylene glycol.
   8. Esters containing no beta hydrogen atoms can withstand temp. 90° F. higher.

F. Fluorcarbons and Chloracarbons
   1. The use of perfluorocarbons as non-reactive diluents was used as a diluent for uranium hexafluoride in the thermal diffusion process for separating the isotopes of uranium.
   2. Later lube oils were the liquid polychlorotrifluorethylenes, the higher polymers were new, unreactive, readily molded, type - now this type polymer is used in extrudable plastics.
   3. Very little used on commercial market now, very low viscosity indexes.
   4. Has very good resistance to heat and gamma radiation
   5. Other studies have been carried out on this group - some good,some bad.

G. Lubricants containing large portions of water
  1. Early types were hydraulic fluids used in elevators - solutions of glycerine and water.
  2. Navy developed a nonflammable hydraulic fluid from glycol-water solution containing approx. 40% water and a water soluble linear polymer to serve as V.I. improver.
    a. A copolymer of ethylene oxide and propylene oxide in a 3:1 proportion.
    b. Corrosion and vapor phase corrosion inhibitor added.
    c. "Hydrolube H-4" = wide range effect.
  3. Shell Oil Co. has produced a water-in-oil emulsion hydraulic oil.

H. Phosphorus Derivatives
  1. Tribochemical reactivity needs careful control at ordinary temperatures by limiting phosphorus additive concentrations.
  2. Also limits the usefulness of such lubes under high temperature wear conditions.
  3. Phosphorus esters also falls into this category of temperature breakdown.
  4. Basis now are for alkyl derivatives.
    a. Found to have good load carrying capacities
    b. Tend to be overactive
    c. May cause excessive erosion of both steels and copper alloys.
    d. May lack thermal stability, perform better at lower temperatures -- less than 250° F.
  5. Triaryl phosphates marketed now for use in industrial hydraulic equipment
  6. Various alkyl - aryl phosphate esters are now patented and applied as less flammable hydraulic oils in commercial aircraft.

I. Other Synthetic Oils
  1. Other organic liquids studied are
    a. Aryl, alkyl, and mixed aryl-alkyd silicates.
    b. The hexa-alkoxy disiloxanes and the octa-alkoxy trisiloxanes.
    c. The tetra alkyl silanes
    d. Impressive results now from polyaryl ethers.

J. Summarization
  1. Synthetic oil molecule must possess boundary lubricating and rust-inhibiting properties and in order to do this must contain one or more polar (or other more reactive) groups which are not hindered from adsorbing or reacting with bearing material.

  2. Investigations now confirm it is better to synthesize liquid lubricants to gain bulk properties such as
   a. High viscosity index.
   b. Low pour point.
   c. Thermal stability
   d. Surface activity needed for wear prevention and rust inhibition.

III. Classes of Synthetic Lubes
 A. Polyglycols.
  1. Linear polymers
  2. High degree of flexibility
 B. Phosphate Esters
  1. Primary and secondary phosphates have found little use as major constituent of synthetic lubricants.
  2. Major utility is that of acids, salts, and amides.
 C. Dibasic Acid Esters
  1. This type result from reacting straight chain dibasic acids, such as sebasic, with branched alcohols
  2. Predominant use is in jet engine lubricants
 D. Chlorofluorocarbon Polymers
 E. Silicones
  1. Synthetic compounds containing the elements silicon and oxygen, and organic groups.
  2. Silicone lubricants are semiorganic polymers and copolymers
  3. Silicone oils are relatively short polymer size chemical structure.
  4. Methyl and Phenyl groups are the substitutes used to vary the properties of silicones
 F. Silicate Esters
  1. Hydrolytic stability limits their usefulness
  2. Have been used as
   a. Heat transfer fluids.
   b. High-temperature hydraulic fluids.
   c. Electronic coolants.
   d. Weapon lubricants
   e. Special low-volatility greases.
 G. Fluoroesters
  1. The synthesis of esters containing fluorinated groups offers a possible method for producing fluids with a wider liquid range than perfluorocarbons.
  2. Much to be studied on this group, still not performing as wanted for all ranges of uses.
  3. Perfluorocarbons hydrolyze readily and cannot be considered suitable for general lubricant applications.

H. Neopentyl Polyol Esters
    1. Organic esters which hold great promise as wide temperature range lubricants with excellent thermal and oxidative stability up to 400° F.
    2. Excellent low-temp. viscosity properties.
    3. High viscosity indices and good lubricity.
    4. Used as high-temp. gas turbine lubricants.
    5. Chemical structure is that of a unique five-carbon structure.

I. Polyphenyl Ethers
    1. Show promise for use in presence of oxygen.
    2. Performs well in high levels of radiation.

J. Novel Synthetic Lubricants
    1. Tetraalkylsilanes
    2. Ferrocene derivatives
    3. Tetra-substituted urea derivatives
    4. Heterocyclic derivatives
    5. Aromatic amines
    6. Hexafluorobenzene

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE:

1. Short test over unit material.
2. Some outside search for material.

UNIT EVALUATION:

The unit is weak at present, but more information could strengthen it.

REFERENCES:

STUDENT:

1. World Book Encyclopedia
2. Synthetic Lubricants - Gunnerson and Hart
3. Any chemistry book

TEACHER:

1. World Book Encyclopedia
2. Synthetic Lubricants - Gunnerson and Hart
3. Chemistry - Sienko and Plane

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: Wayne Dickerson
Senior High School
Lindsborg, Kansas

INSTRUCTIONAL LEVEL: Junior High - Senior High - College

TITLE: Preparation of a Lithium Soap Grease

PRESENTATION TIME: 20 minutes

INTRODUCTION:

Lubricating greases, a combination of a petroleum product and a soap or a mixture of soaps, suitable for certain types of lubrication, is a very broad statement. Being a soap-thickened oil used for a substitute for lubricating oil in locations where unsatisfactory oil retention makes the use of a grease more desirable. By making this grease, one can definitely see that really it is the oil that is the principal lubricating factor.

OBJECTIVES:

1. To point out the specific chemical make-up of an ordinary grease so that the student is more aware of its quality, physical, and chemical structure.
2. To actually perform the experiment and see the end results.
3. To show what bleed-out is and know how it is controlled.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Power Mechanics

INTER-RELATION WITH OTHER SUBJECTS:

Other Industrial ARts subjects such as Metals, Woods, and Plastics. Vocational Agriculture could use this unit.

USE IN INDUSTRY:

Industry is constantly searching for new and better greases for the modern day machines. As long as we have machines, there will always be this need for lubricating greases. The space age industries have studied long and hard to come up with lubes for their vehicles.

MATERIALS AND EQUIPMENT:

1. Several types of greases (visual inspections).
2. Ivory soap.
3. 250 ml. Beaker (2)
4. Hard wood stirring sticks.
5. Small electric or gas hot plate.
6. Small container of lithium chloride - 1 m.
7. White mineral oil.
8. Small containers of powdered zinc, powdered aluminum or colloidal graphite, and 3% molybednum sulfide powder.
9. A 300° F. thermometer.

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT:

SAFETY:

Have asbestos gloves, a hooded exhaust fan, a thermometer along with the set up. Watch the boiling material and don't let it overflow.

PRESENTATION:

(See attached enclosure)

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE:

1. Make up a small portion of the grease as directed in the presentation section.
2. Will be tested over procedure.

UNIT EVALUATION

1. Will give a clear and concise meaning to lubricating greases.
2. Unit test portion of lubrication test.

DEFINITION OF TERMS:

Explained in unit preparation.

REFERENCES:

STUDENT:

Mimeographed sheets will be handed out for the performance.

TEACHER:

1. Shell Handbook - Shell Oil Company
2. Louie Melo - workbook.

THE PREPARATION OF A LITHIUM SOAP GREASE

Weigh 5 grams of shavings of Ivory white soap (assume it is a sodium stearate soap) on the laboratory balance to approximately 5 grams. Transfer it to a clean, dry 250 ml. beaker. Add about 60 ml. of 70° C. water. Stir and heat a little while the soap is dissolving. If the hot soap solution contains any black rust specks from an iron can in which it has been stored, carefully decant it into another clean beaker. Now add 30 ml. of 1 molar (1 M.) lithium chloride solution and stir well for about one minute.

$$C_{17}H_{35} - COONa + LiCl \qquad\qquad C_{17}H_{35}COOLi + NaCl$$

insoluble lithium stearate

Filter, using a slight suction. Wash the lithium soap with about 4 portions of 40 ml. each of 70° C. water. Pull the soap dry for 5 or 10 minutes; then transfer it to a dry beaker. Add 50 ml. of white mineral oil. Heat on a wire screen over a low flame with constant stirring. As soon as the oil and soap gets up to about 100° C. it will begin to foam. This thing can easily foam over and make a mess. This is unnecessary. As soon as the foam gets within an inch of the top of the beaker, lift the beaker and set it on the desk to cool a little; then continue heating. Stir all the time. Continue this heating and stirring until the oil changes from the first chalky white color to the first clear translucent color. Stop heating at once. Continue to stir and all the chalky color will probably disappear leaving a clear semi-translucent color.

When cool, the grease should set. If it does not, heat again.

Summing up, you have made a gelatinous insoluble lithium soap. This soap carried considerable free water in a mechanical bond. The soap mixed with oil frothed when heated due to the excess water. Heating with constant stirring drove out the excess water and this turning point was indicated by the change in color noted above. If one passes this point too much the grease gets stringy when hot and hard and leathery when cold.

Lithium soap greases are known as "all purpose" greases, i.e., water pump, wheel bearing, and chasis lubrication.

A lithium soap grease may have 1% to 4% powdered zinc, powdered aluminum, or colloidal graphite added to it for rock crusher and other heavy machinery bearing lubrication. Or it may have 1% to

3% molybednum sulfide powder (flake) added and we now have the new 30,000 mile or lifetime grease of the new car.

These powders are available and you may use them. It is optional.

OTHER SOAP GREASES

A 5 gram portion of Ivory soap in hot water (70° or 80° C.) may be used in all cases.

A 12 ml. to 15 ml. portion of Ni^{+2}, Cu^{+2}, Co^{+2}, or Zn^{+2} of one molar will be sufficient to precipitate all the soap. The resulting insoluble soaps can be filtered using a little suction. Use a 50 ml. portion of white paraffin oil.

These insoluble soaps hold considerable water. When the soap and oil are first heated the water causes frothing or foaming. Continued heating near 100° C. steam may form at the bottom of the beaker under the oil. Its escapement is accompanied by a sharp crackling sound. This is a danger sign. Stop heating at once. Let the sample cool. Some water may be removed mechanically before continued heating.

Aluminum soap grease is easily made.

Chromium and iron soap greases are a waste of time.

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: Roger L. Barnes
Horace Mann Junior High School
Colorado Springs, Colorado

INSTRUCTIONAL LEVEL: 7th and 8th Grade

TITLE: Structure of Petroleum Hydrocarbons

PRESENTATION TIME: 15 to 20 minutes

INTRODUCTION:

All petroleum substances have one thing in common. They are made up entirely of carbon and hydrogen. Of course in crude petroleum there are other materials present, but these are considered to be impurities. In refining all but the smallest amounts of the impurities are removed.

Since there are hundreds of different petroleum products, it is important to consider how carbon and hydrogen are combined so that all of these different compounds can be produced from only two elements. When carbon and hydrogen combine into a single molecule, this molecule is called a hydrocarbon. It is hydrocarbon that we are interested in learning more about.

OBJECTIVES:

To give the student an understanding of the structure of hydrocarbons.

To relate the hydrocarbon make up to the characteristics of a material.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA:

INTER-RELATION WITH OTHER SUBJECTS:

Organic chemistry is the basis for understanding petroleum hydrocarbons and other fields of science are also used as tools in dealing with petroleum. So a strong relationship can easily be established for the student between petroleum and science.

In industrial arts, petroleum can be related to almost all areas in either a direct or indirect manner. When we consider fuels, lubricants, solvents, and the numerous synthetic materials, it can be seen that petroleum is the source of many of the basic materials we use.

USE IN INDUSTRY:

All industries use one or many of the products derived from petroleum. It furnishes fuels to produce power, lubricants for the machinery, and many of the chemicals and products used as raw materials. The relationships of petroleum materials to industry and to industrial arts are nearly identical. So it can be said that petroleum is one of the base materials of our technological society.

MATERIALS AND EQUIPMENT:

A. Overhead projector
B. Movie projector

EDUCATIONAL MEDIA:

A. Set of overhead transparencies
B. Films (suggested)
    1. Carbon and its Compounds
    2. Chemical Bonds and Atomic Structure
    3. Hydrocarbons and their Structure
       Coronet Films
       65 E. South Water Street
       Chicago, Illinois 60601
C. Set of two informational charts

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT:

SAFETY:

In any discussion of petroleum and petroleum products, it should be stressed throughout that they can be dangerous materials. For example, most of the materials are flammable and will ignite easily. Many others are highly explosive. Also, with the gaseous materials there is the danger of asphyxiation. This is equally true with carbon monoxide which is the by-product of combustion of hydrocarbon fuels. Therefore, when working with hydrocarbons in most forms, it is wise to exercise caution.

PRESENTATION:

1. Structure of hydrocarbons
    a. Carbon
        (1) Size and structure of atom
        (2) Chemical notation
        (3) Ability to join together (valence)
    b. Hydrogen
        (1) Size and structure of atom

- (2) Chemical Notation
- (3) Ability to join with carbon
- (4) Number of hydrogen atoms that will join to one carbon

c. Types of hydrocarbon molecules
   - (1) Saturated molecules
   - (2) Unsaturated molecules
   - (3) Isomers
   - (4) Ring or cyclic molecules

2. Hydrocarbon Characteristics
   - a. Gaseous hydrocarbons
     - (1) Natural and LP Gas
     - (2) Small number of carbon atoms
     - (3) Low molecular attraction
     - (4) Low boiling points
   - b. Liquid Hydrocarbons
     - (1) Gasoline to heavy lub oils.
     - (2) Size of molecules in liquid range
     - (3) Increase of molecular attraction with increase of size of molecule
     - (4) Boiling range of gasoline, kerosene, fuel oil, lub oil, and etc.
   - c. Solid hydrocarbons
     - (1) Asphalt and waxes
     - (2) Very large complex molecules
     - (3) Strong molecular attraction
     - (4) Melting and boiling points
3. Petroleum Hydrocarbon Products
   - a. Natural and LP gas
   - b. Gasoline
   - c. Kerosene
   - d. Diesel and jet fuel
   - e. Heating oil
   - f. Lubricating oils
   - g. Greases
   - h. Asphalt
   - i. Waxes
   - j. Solvents
   - k. Synthetics
     - (1) TNT
     - (2) Orlon
     - (3) Anti freeze
     - (4) Photo film
     - (5) Teflon
     - (6) Lucite

(7) Butyl rubber
(8) DDT
(9) Detergent
(10) There are 3,000 or more products in this group.

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE:

1. Quiz
    a. What is the chemical symbol for carbon? for hydrogen?
    b. How many hydrogen atoms will join to one carbon atom?
    c. What is the name of a molecule made up of carbon and hydrogen?
    d. Which is larger--a molecule of natural gas or gasoline?
    e. Why does natural gas boil at temperatures far below 0° F.?
2. Observation of student response to presentation of the unit.

UNIT EVALUATION:

1. Item analysis of the quiz.
2. Student response and interest in unit.
3. Questions raised by the students.

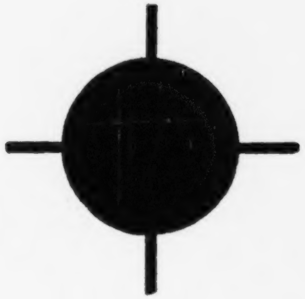
DEFINITION OF TERMS:

1. Petroleum - the oil that is obtained from the earth.
2. Hydrocarbon - a compound made up of hydrogen and carbon.
3. Organic - a substance which is living or was once alive.
4. Volatility - the ability or tendency to turn to vapor (boil).
5. Isomer - different forms of one hydrocarbon molecule.
6. Synthetic - a material that does not occur in nature. It is produced artificially.

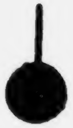
REFERENCES:

The Story of Gasoline, Ethyl Corporation

HYDROCARBONS

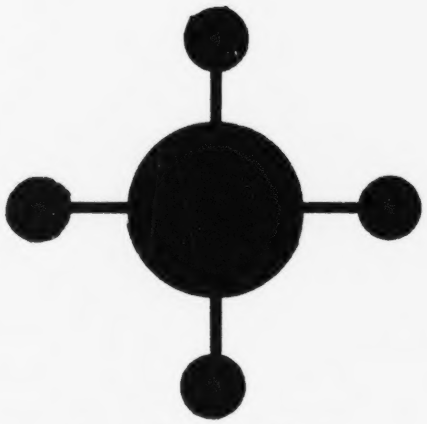


CARBON ATOM
(C)

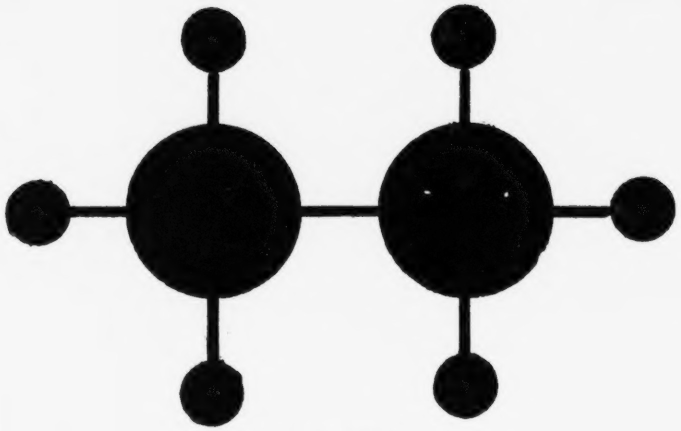


HYDROGEN ATOM
(H)

NATURAL GAS

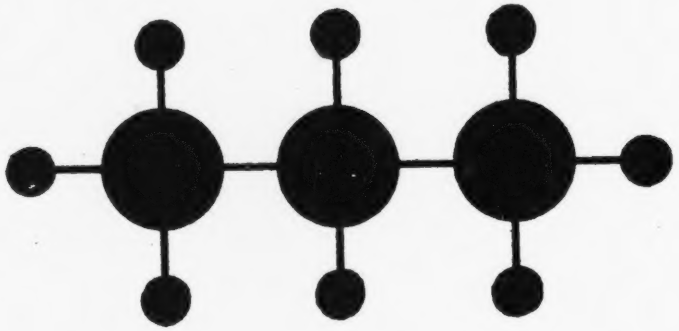


METHANE
CH_4



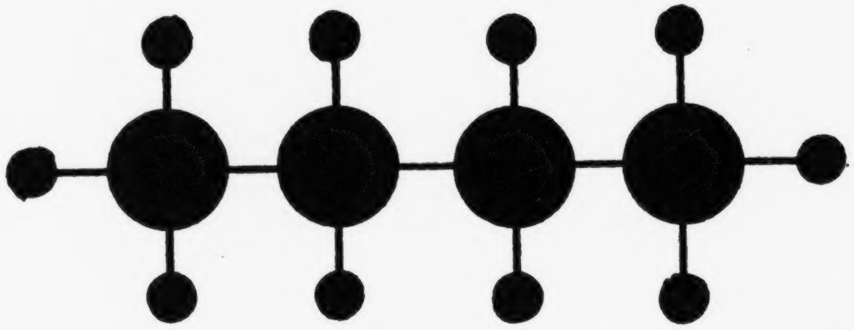
ETHANE
C_2H_6

LIQUIFIED PETROLEUM GAS (LPG)



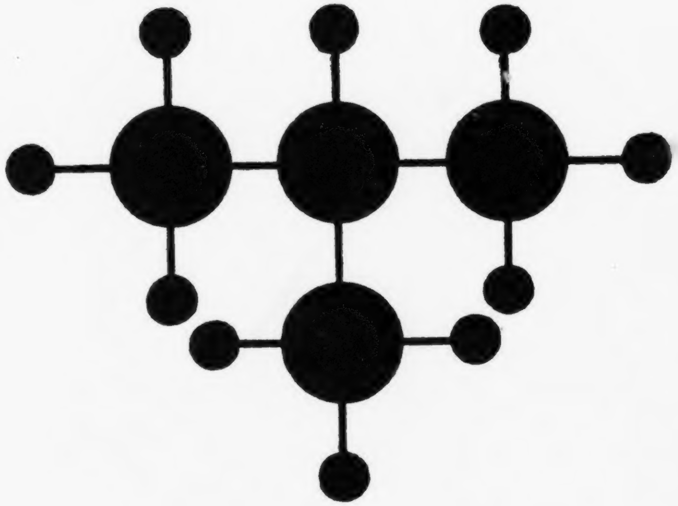
PROPANE

C_3H_8



BUTANE

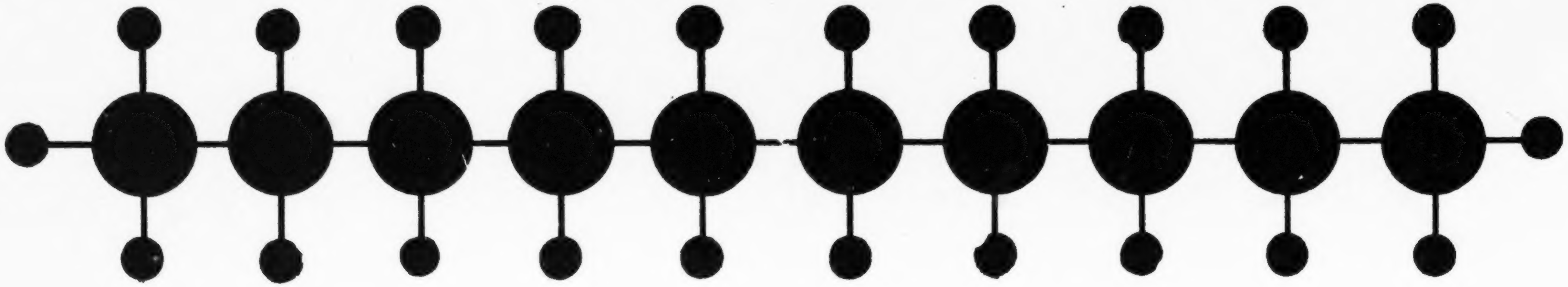
C_4H_{10}



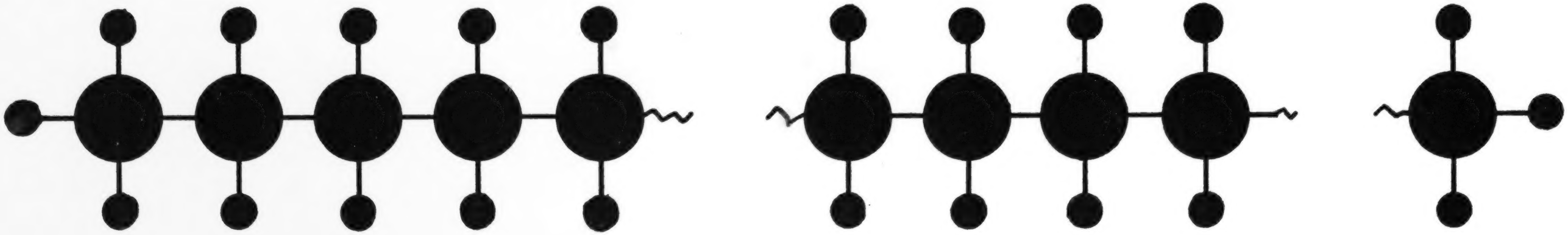
ISO BUTANE

C_4H_{10}

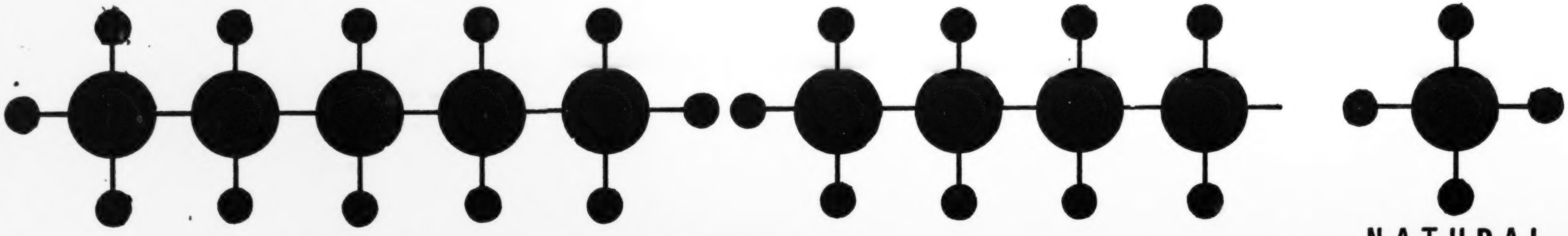
CRACKING



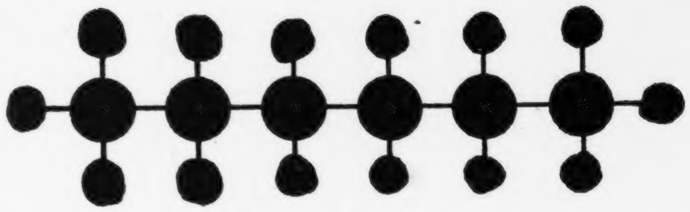
KEROSENE (DECANE $C_{10}H_{22}$)



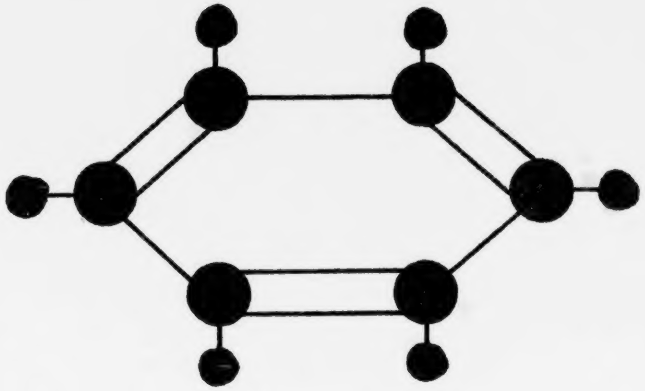
HYDROGENATION (ADD 4 H^-)



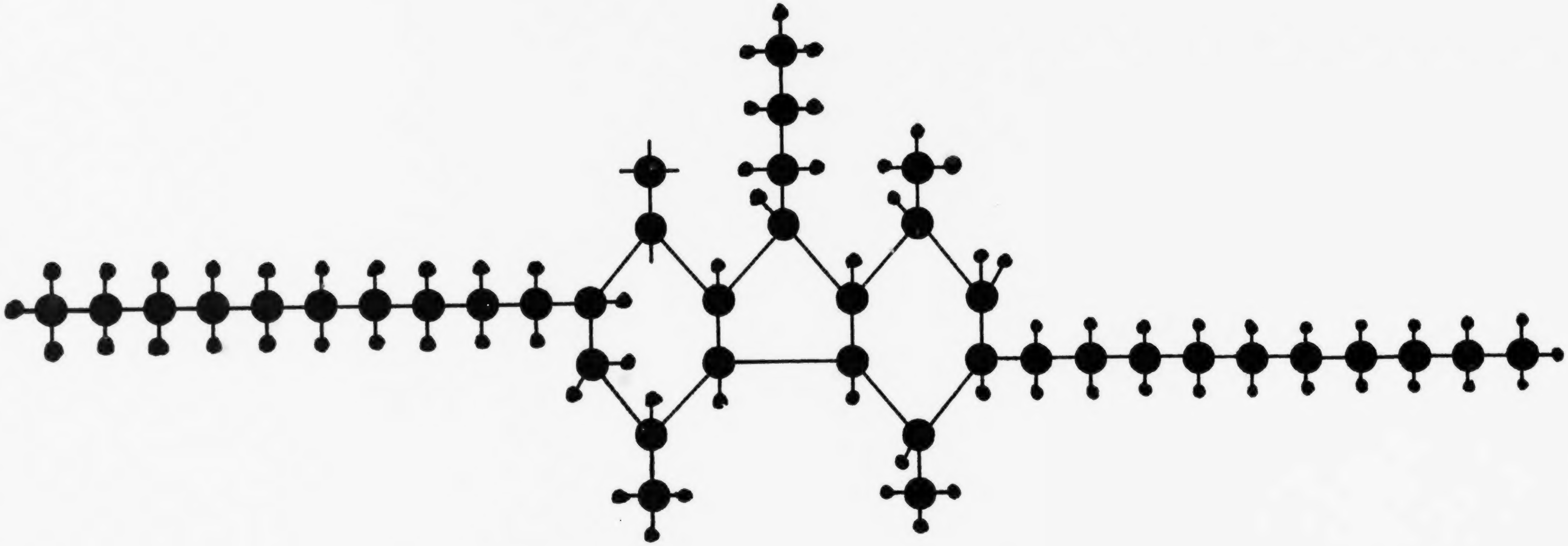
GASOLINE (PENTANE C_5H_{12}) L P GAS (BUTANE C_4H_{10}) NATURAL GAS (METHANE CH_4)



HEXANE
(GASOLINE)



BENZENE
(SOLVENT)



LUBRICATING OIL MOLECULE

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL MATERIALS

PRESENTED BY: L. Wayne Dickerson
Senior High School
Lindsborg, Kansas

INSTRUCTIONAL LEVEL: Jr. High - Sr. High - College

TITLE: Theory and Principles of Oil Lubrication

INTRODUCTION:

Lubricants have many important functions to perform in the automobile and other types of machines. They must guard against the development of excessive heat produced by friction between moving parts. They must also carry generated heat away from the moving parts to a place where it can be transferred to the air or to water. This last function is especially true of cutting oils.

In order to accomplish the two tasks - reduce friction and remove heat, lubricants must have special properties and characteristics.

OBJECTIVES:

1. To show why oils must have specific properties and how these properties affect the machine parts.
2. To learn some of the functions oils must perform
3. To learn to select and use the proper kind of oils.
4. To learn why current oils are more durable than past oils.

INTER-RELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Power Mechanics

INTER-RELATION WITH OTHER SUBJECTS:

Other Industrial Arts subjects which may use this unit are woods, metals, graphic arts. The science classes can use this unit to a very good advantage, both in theory and in practice.

USE IN INDUSTRY:

Design engineers, production engineers and industry as a whole place a great emphasis on this important field. Old manufacturing systems as well as the newest procedures require a thorough understanding of all the newest and latest facts about lubricants. The major oil companies are spending great amount of money in lubrication research. The space program offers many new avenues of exploration along this line.

MATERIALS AND EQUIPMENT:

1. Samples of various oils.
2. Simple metal friction plates, to demonstrate friction.
3. Micrometer, 0-1".
4. Beaker and water, to show viscosity principle.
5. Roller bearing, to show wedge friction action.

EDUCATIONAL MEDIA:

Film - Refining Oil for Energy - American Oil Co.
Distillation transparencies
Lubrication transparencies
Test demonstrations to set up.

UTILIZATION IN THE TEACHING-LEARNING ENVIRONMENT:

PRESENTATION:

I. Duties and Properties of Lubrication Oils
    A. Lubricating oils must perform four jobs.
        1. Minimize friction and wear - sliding or rolling
            a. Friction may be defined as the resistance to movement between any two objects when placed in contact with each other.
                1) Desirable friction
                2) Undesirable friction
            b. Two kinds of friction are, dry friction and wet friction. Sometimes referred to as solid friction and fluid friction
                1) Dry friction is when both rubbing parts are clean and free of other materials
                2) Wet friction is when rubbing parts have other material or materials placed between them.

"Friction Plate Experiment"

            c. Bearing construction plays a part in determining the amount of friction involved. Two kinds:
                1) Friction bearing - solid or sliding friction
                2) Anti-friction bearing - rolling friction
            d. Oil or "Viscous" lubrication acts as thin film interposed between the surfaces to substitute internal fluid friction for the solid friction.
                1) Oil viscosity refers to the thickness or fluidity of the oil. It is a measure of an oil's ability to resist flowing.

Water and Beaker Experiment
Viscosity Classificaiton Chart
Viscosity Comparison Chart
Composite Chart

      - 2) Oils thin out when heated and thicken when cooled.
      - 3) Viscosity Index is a classification based on flow at different temperatures.

Wedge and Non-wedge Action Chart

    - e. Wearing quality of oil
      - 1) Does not wear out
      - 2) Only becomes contaminated
    - f. Depletion of additives may cause corrosion and sludge to form
      - 1) Additives are chemical materials added to lubricating oil to increase its effectiveness.
      - 2) These contain detergent/dispersent, oxidation inhibitors and other specific additives.
      - 3) Almost complete lists of additives may be obtained from oil companies.
    - g. Oil changes should be made more frequently
      - 1) Operated under extreme conditions.
      - 2) Stop and go driving in cold weather.
      - 3) Dust storms during any time of year.
      - 4) Crankcase ventilating system not functioning properly.
      - 5) Engine in poor condition
      - 6) Air cleaner becomes clogged
      - 7) Carburetion system not function properly.
    - h. How oils work - bearing clearances.
      - 1) Full pressure, splash oiling and combination splash and pressure systems.
      - 2) Two cycle engine operation

Bearing Principle Charts

  - 2. Assist in cooling the engine
    - a. Friction generates heat, heat causes wear and the engine loses a portion of its potential power.
      - 1) Heat transfer - three methods
        - a) Conduction - physical contact
        - b) Convection - fluid or gas movement
        - c) Radiation - energy given off in all directions
    - b. Coolants may be solids, liquids, emulsions or gases.
    - c. Must reduce Coefficient of Friction.
      - 1) Reduce friction and temperature of parts.
      - 2) Improve surface finish
      - 3) Reduce power loss required to operate
    - d. Additives provided to improve cooling quality

        1) Fight bearing corrosion
        2) Keep small foreign particles in suspension
        3) Reduce oxidation
        4) Minimize carbon, lacquer and gum formation
3. Provides a sealing quality
    a. Helps piston rings seal cylinder
    b. Assists in sealing around valve stems
    c. Assists various oil seals in engine
    d. Assists valve lifters to perform their duties
4. Keeps the engine relatively clean
    a. Carries larger particles to sump
    b. Picks up dry gases from crankcase
    c. Corrosion preventative added to prevent acidic gases

EVALUATION AND OBSERVATION

STUDENT PERFORMANCE:

1. Materials Process Tests will be performed at end of unit.
    a. Friction Tests
    b. Flash and Fire Tests
    c. Specific Gravity Test
    d. Viscosity Tests
    e. Roller and Ball bearing experiment
2. Large unit test

UNIT EVALUATION:

1. Check and recheck for weaknesses
2. Large Unit Test
3. Changes evident for further teaching of unit.

REFERENCES:

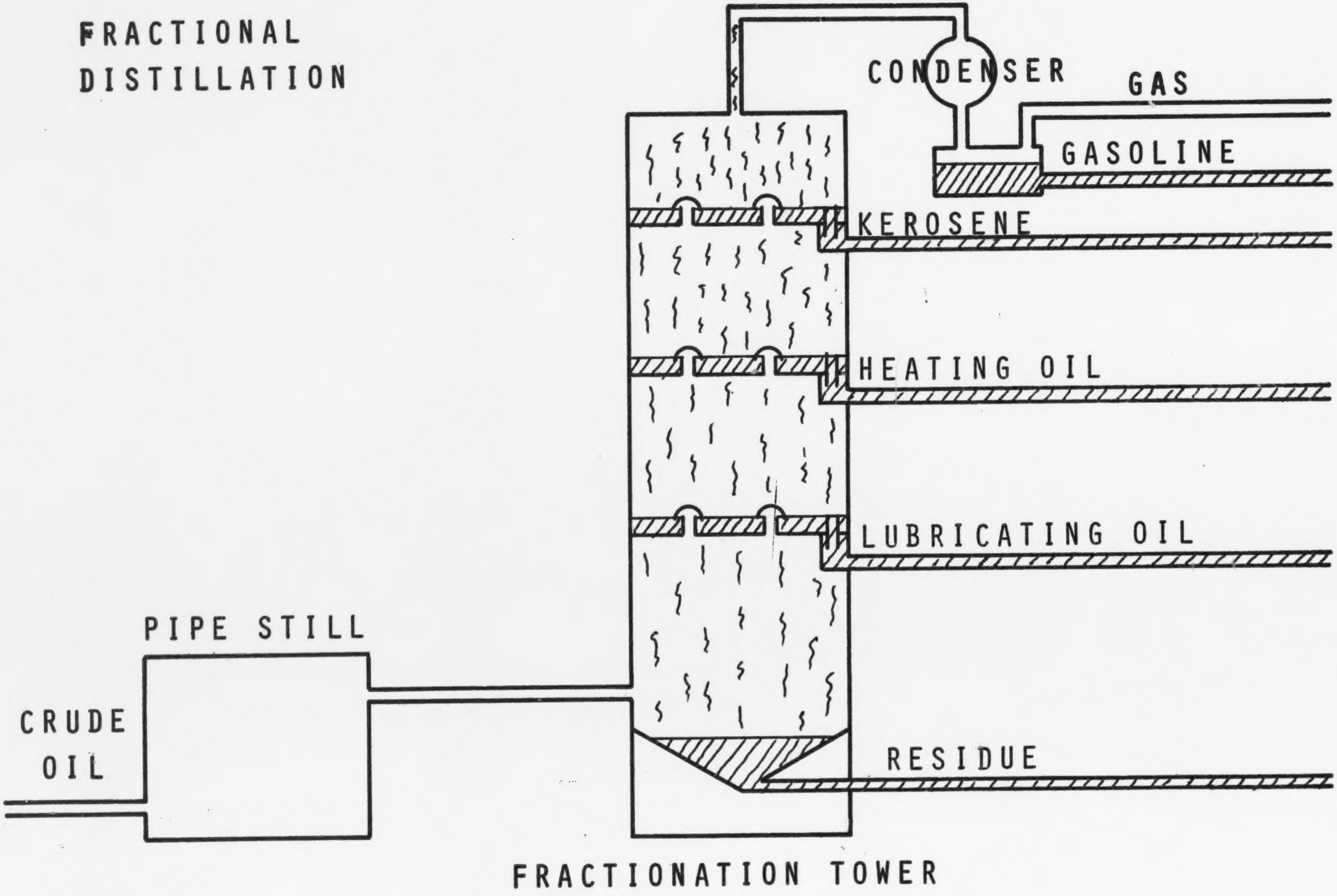
STUDENT:

1. Stockel, Martin W., Auto Mechanics Fundamentals, Homewood, Ill. Goodheart-Willcox Co., Inc., 1963, Ch. 5-1.
2. Film - Refining Oil for Energy, American Oil Co.

TEACHER:

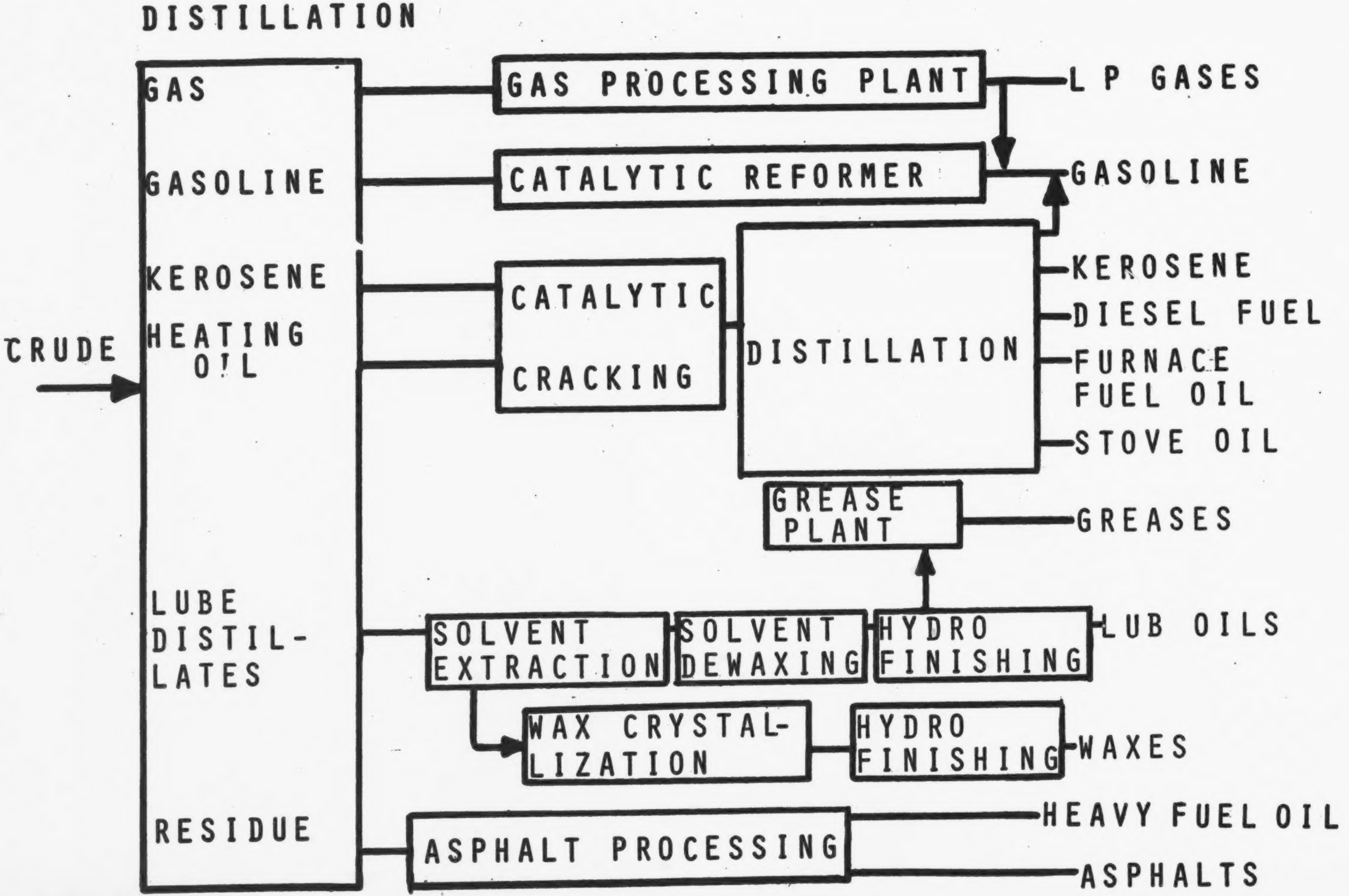
1. Popovitch, M., Fuels and Lubricants, New York: John Wiley and Sons, Inc., 1959, Ch. 10.
2. Kock, G. P., Ph.D., Handbook of Shell Products, San Francisco, Calif., Shell Oil Co., 1938 - Lub. section
3. A.S.T.M. Standards, Part 17, 1967.

FRACTIONAL DISTILLATION

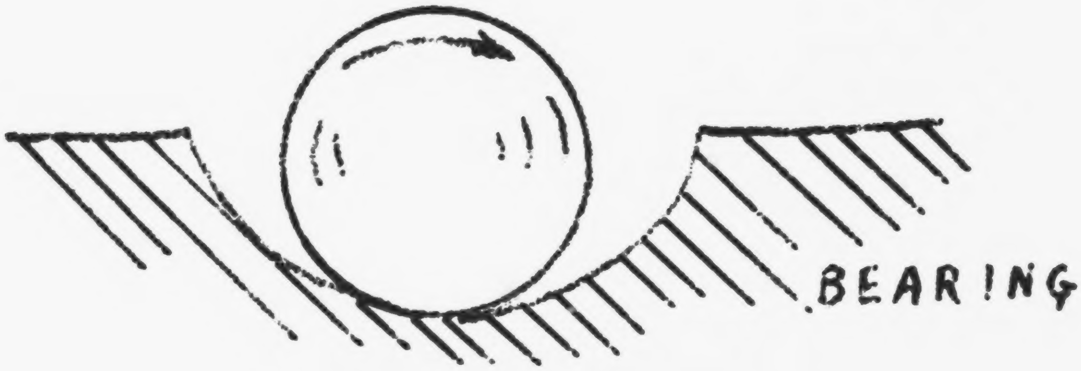

CONDENSER
GAS
GASOLINE
KEROSENE
HEATING OIL
LUBRICATING OIL
RESIDUE
PIPE STILL
CRUDE OIL
FRACTIONATION TOWER

T-1

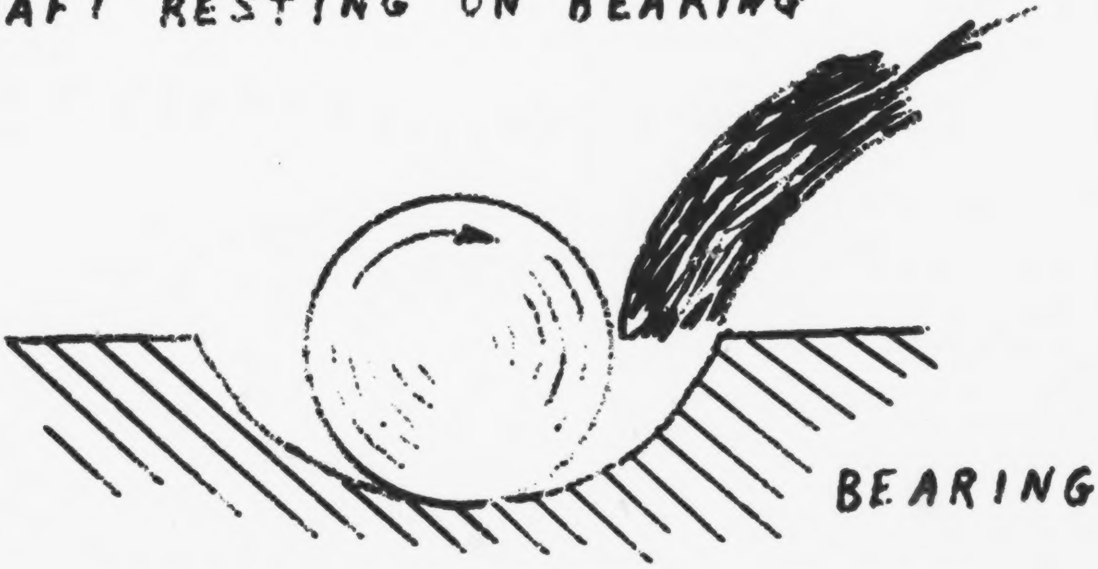
SIMPLIFIED FLOW THROUGH A REFINERY


DISTILLATION
CRUDE
GAS
GASOLINE
KEROSENE
HEATING OIL
LUBE DISTILLATES
RESIDUE
GAS PROCESSING PLANT
CATALYTIC REFORMER
CATALYTIC CRACKING
DISTILLATION
GREASE PLANT
SOLVENT EXTRACTION
SOLVENT DEWAXING
HYDRO FINISHING
WAX CRYSTALLIZATION
HYDRO FINISHING
ASPHALT PROCESSING
L P GASES
GASOLINE
KEROSENE
DIESEL FUEL
FURNACE FUEL OIL
STOVE OIL
GREASES
LUB OILS
WAXES
HEAVY FUEL OIL
ASPHALTS

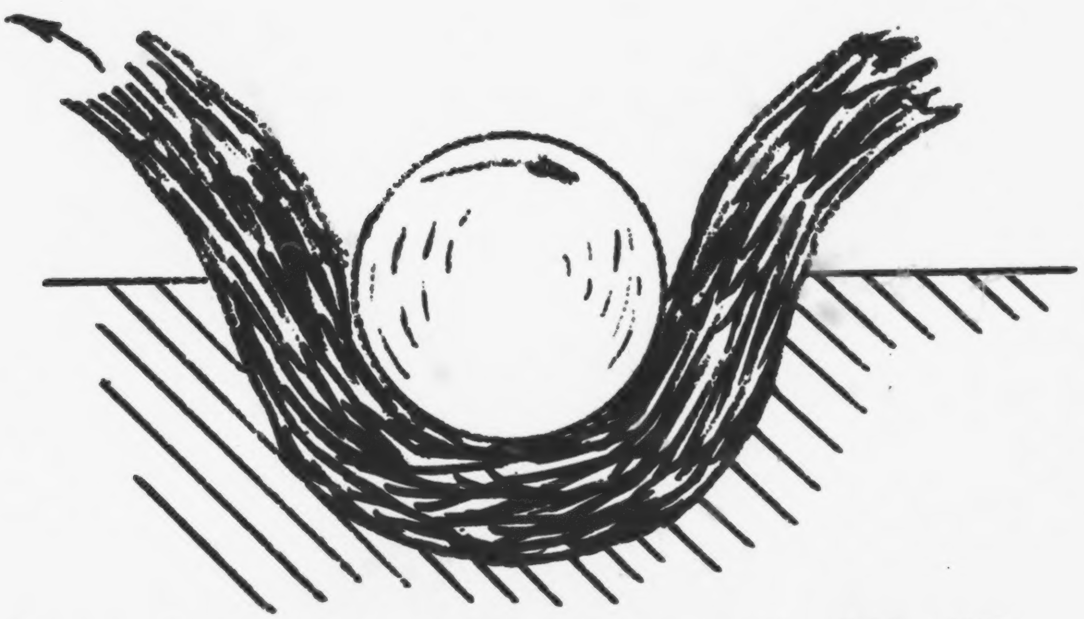
HOW OIL ENTERS BEARING (SPLASH)



1. SHAFT RESTING ON BEARING

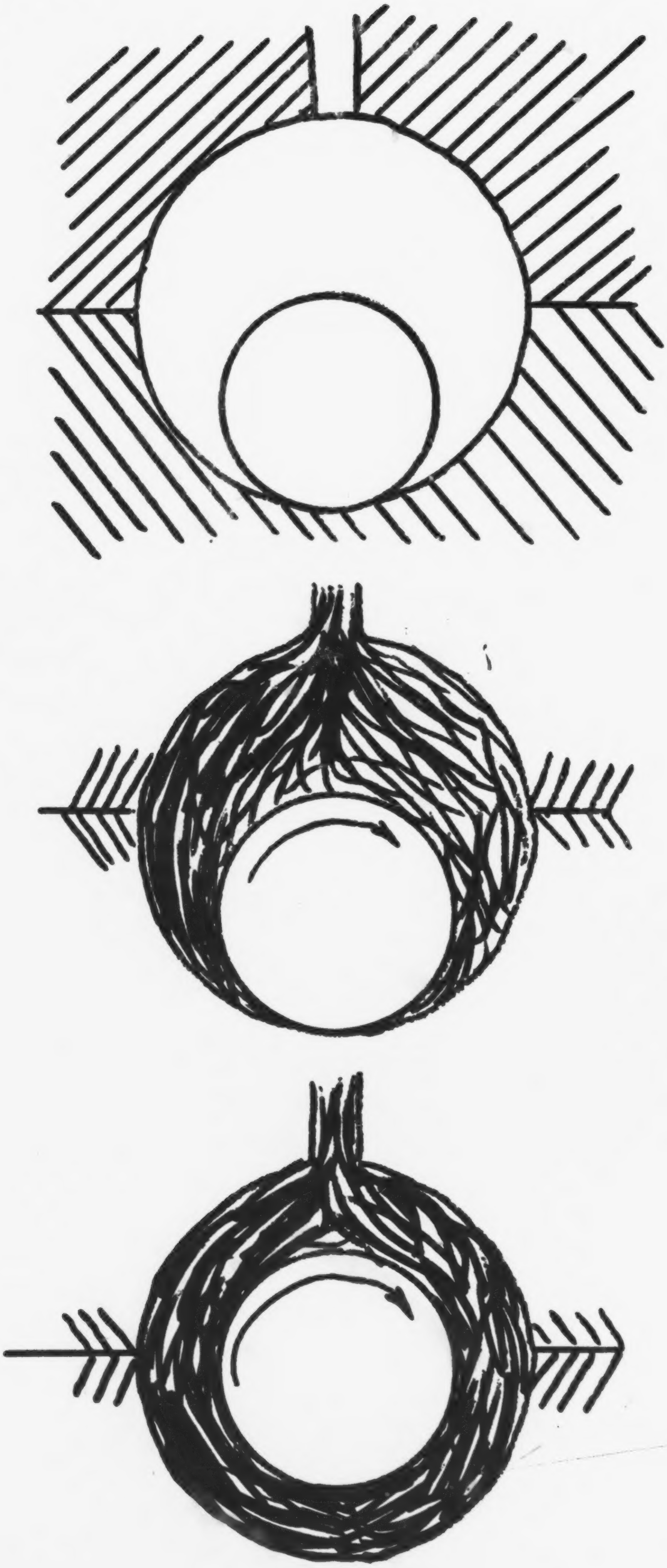


2. OIL ENTERING BEARING



3. OIL PULLED THROUGH BY SHAFT
SHAFT NOW FREE OF BEARING

ct



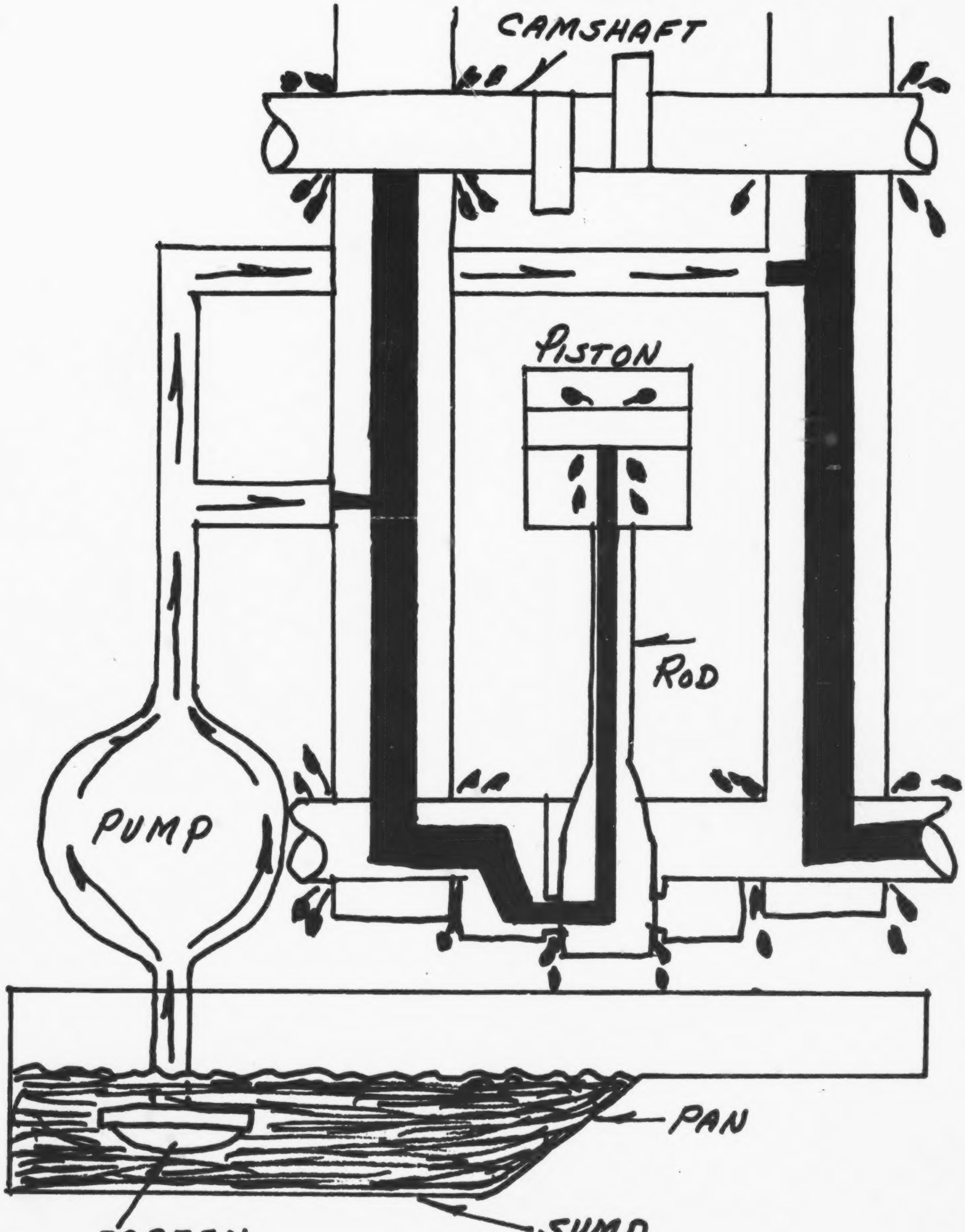
RESIDUAL OIL ONLY - SHAFT RETSON BEARING

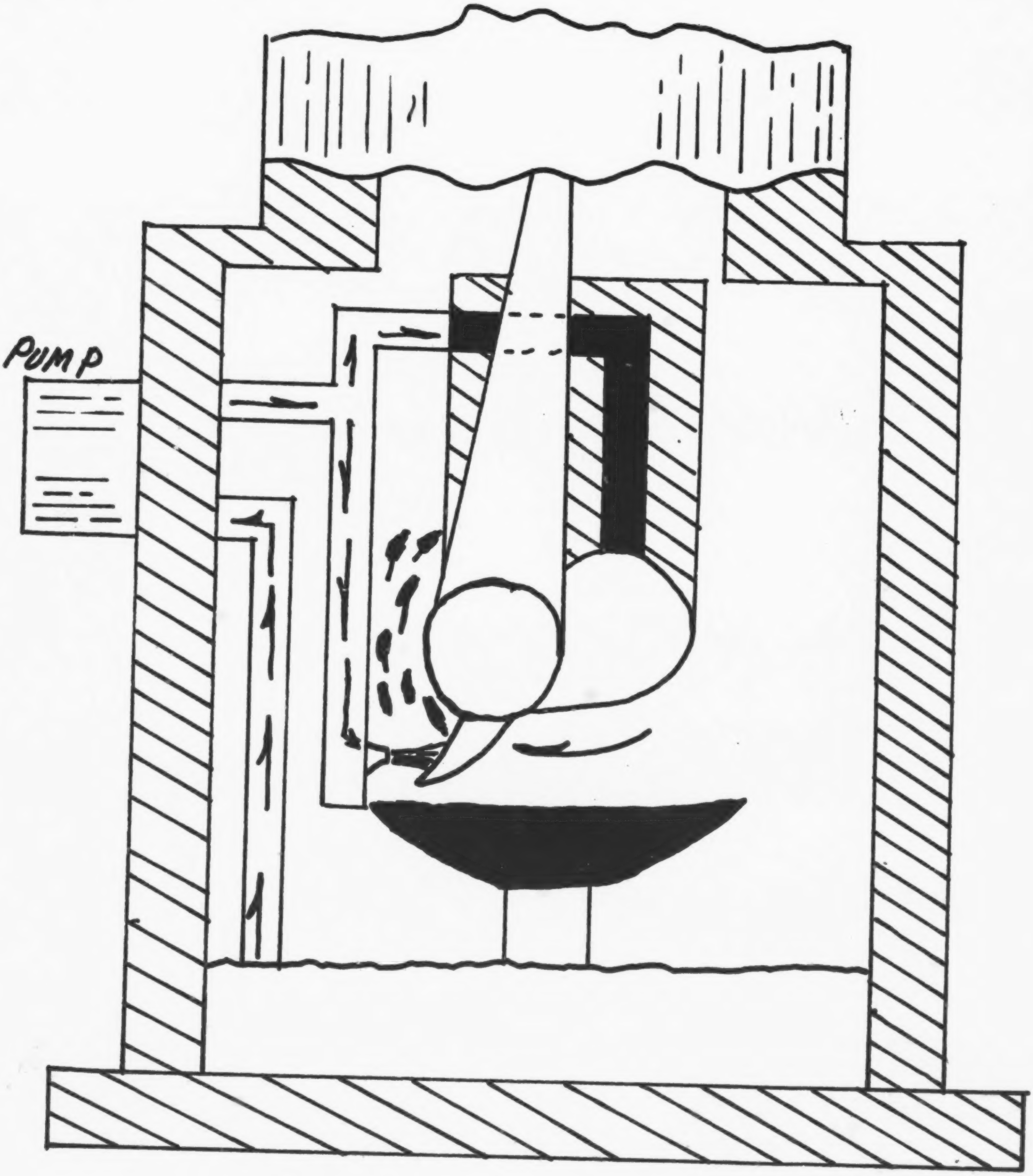
OIL ENTERING JOURNAL SHAFT ROTATING

OIL HAS WEDGED SHAFT UP - BEARING AND JOURNAL WILL NOT TOUCH

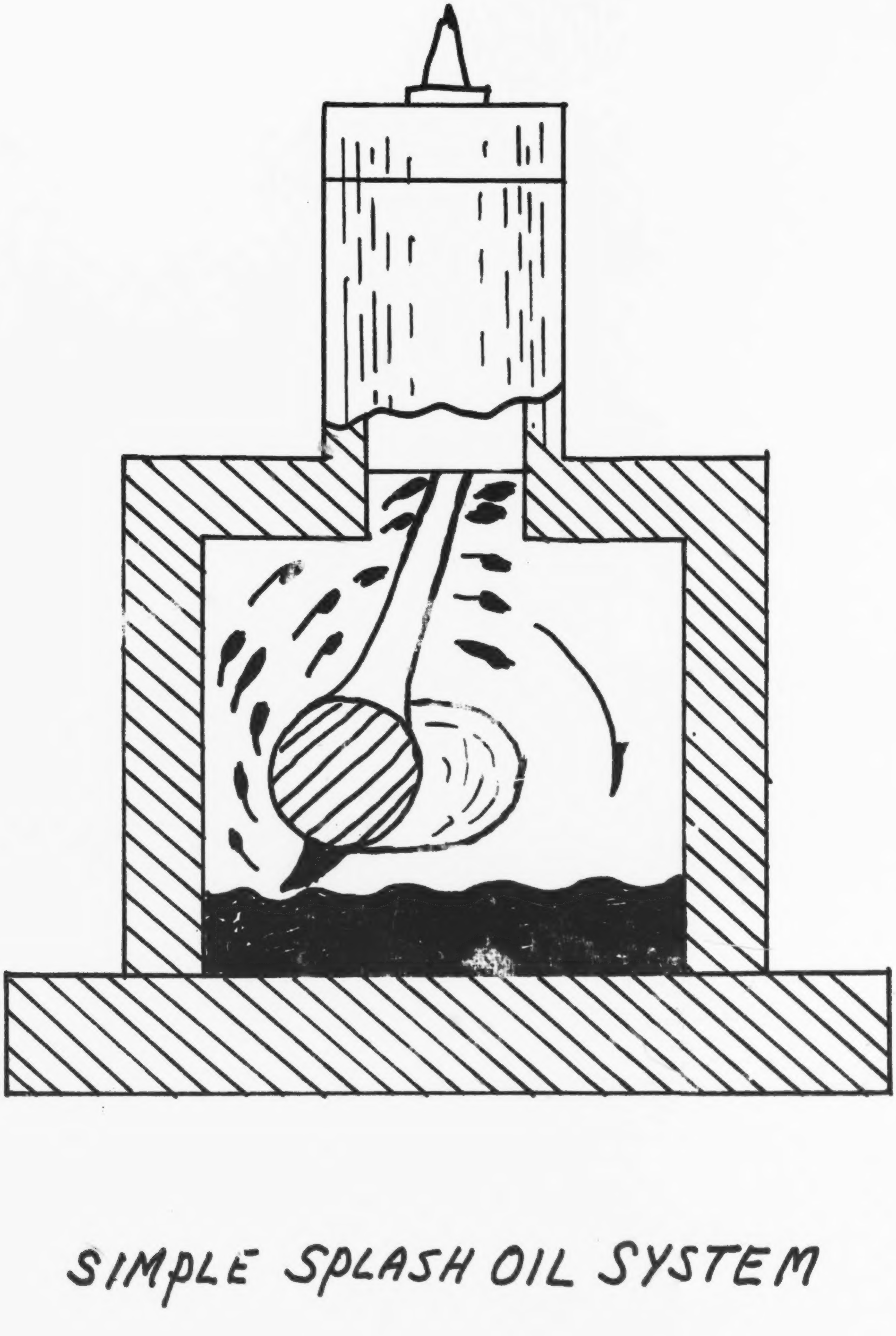
HOW OIL ENTERS BEARING (PRESSURE) d

FULL PRESSURE SYSTEM

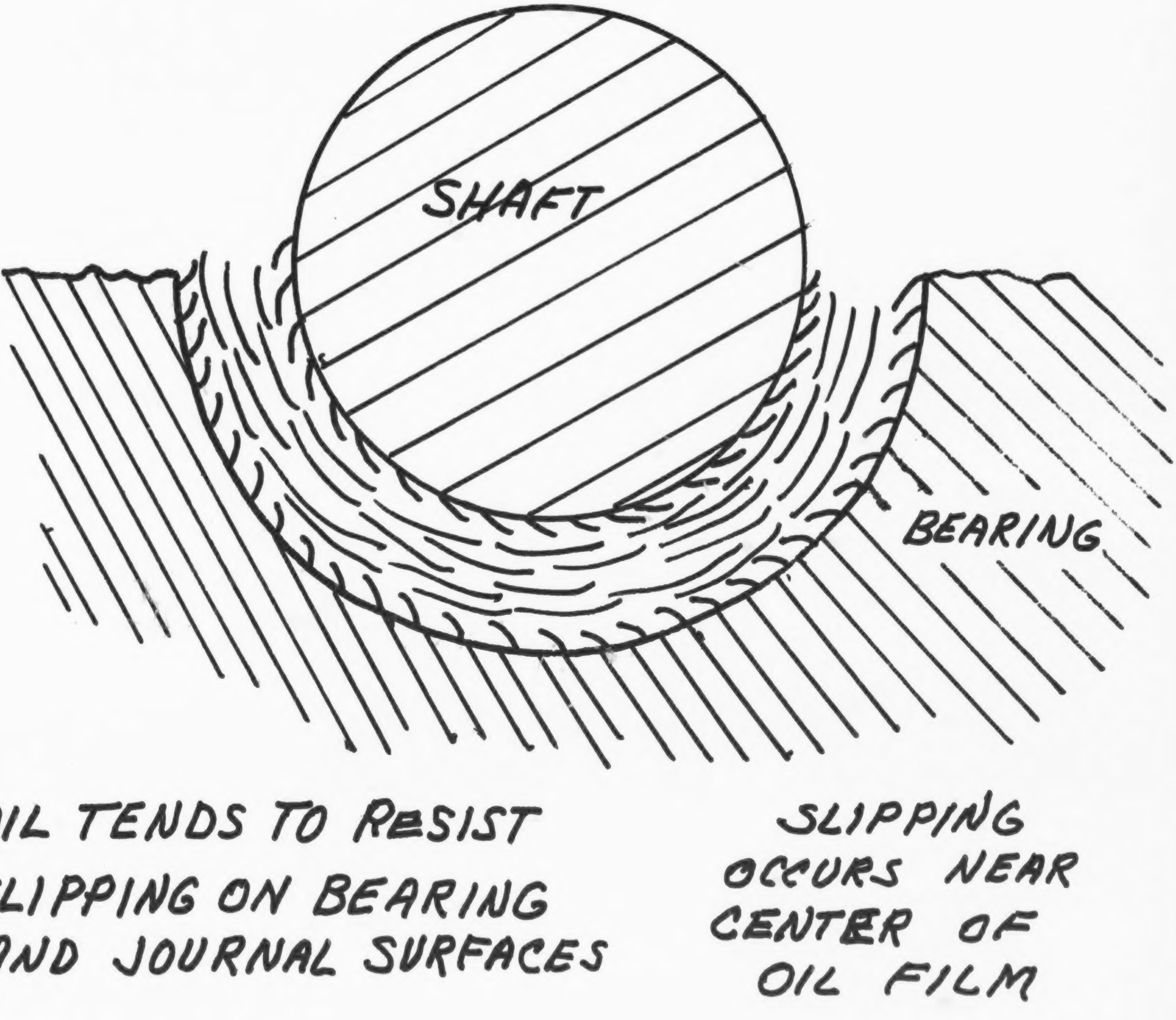

CAMSHAFT
PISTON
ROD
PUMP
PAN
SCREEN
SUMP



COMBINATION SPLASH & PRESSURE OILING SYSTEM



SIMPLE SPLASH OIL SYSTEM

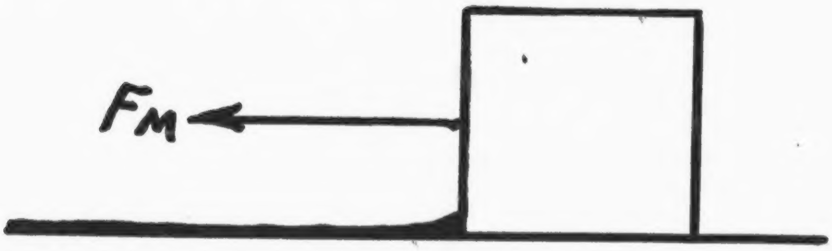

SHAFT
BEARING

OIL TENDS TO RESIST SLIPPING ON BEARING AND JOURNAL SURFACES

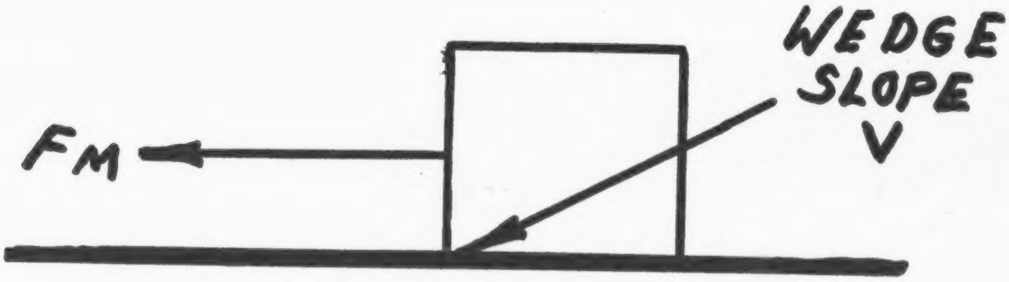
SLIPPING OCCURS NEAR CENTER OF OIL FILM

ACTION OF OIL IN BEARING

d



WEDGE ACTION
NOT OBTAINED


FM
WEDGE
SLOPE
V

WEDGE ACTION
INDUCED BY SLOPE V

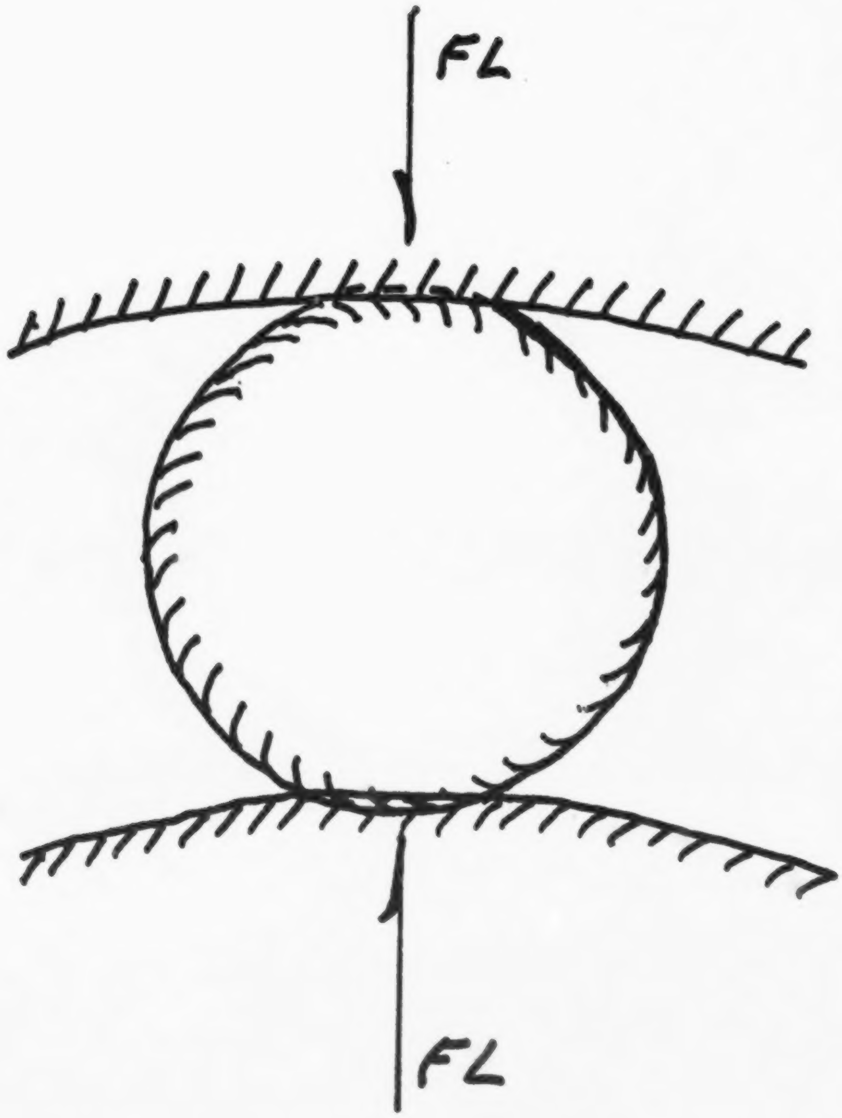
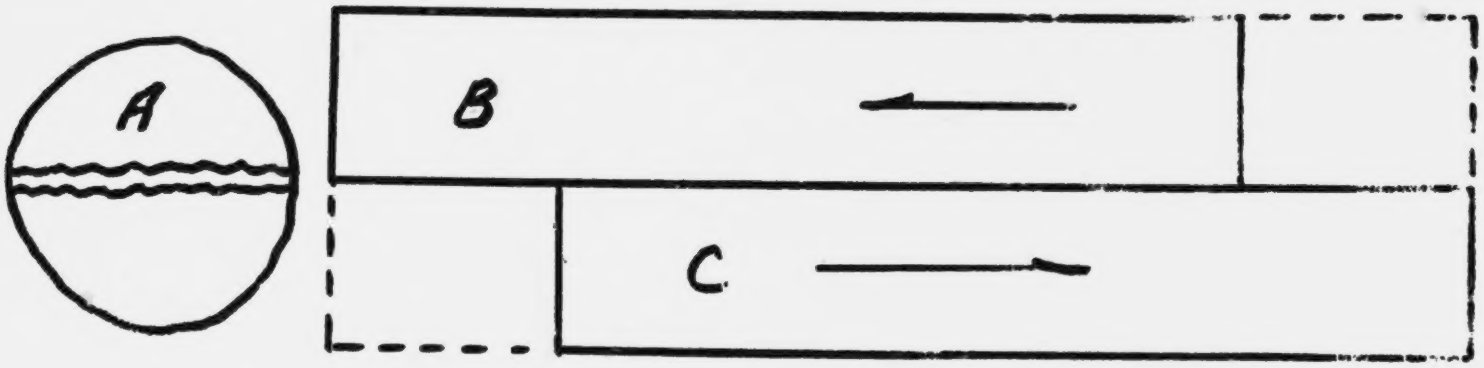
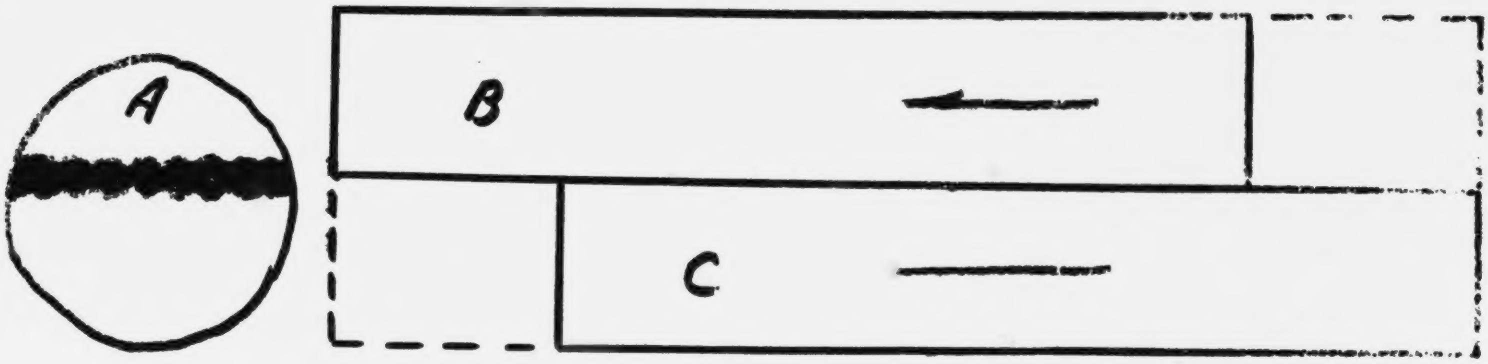


DIAGRAM TO SHOW DEFORMATION OF A BALL BEARING AND RACES UNDER LOAD



NO LUBRICANT ADDED - SOLID FRICTION



LUBRICANT ADDED - FLUID FRICTION

SEPARATING SURFACES OF BEARINGS WITH LUBRICANTS

TABLE 3

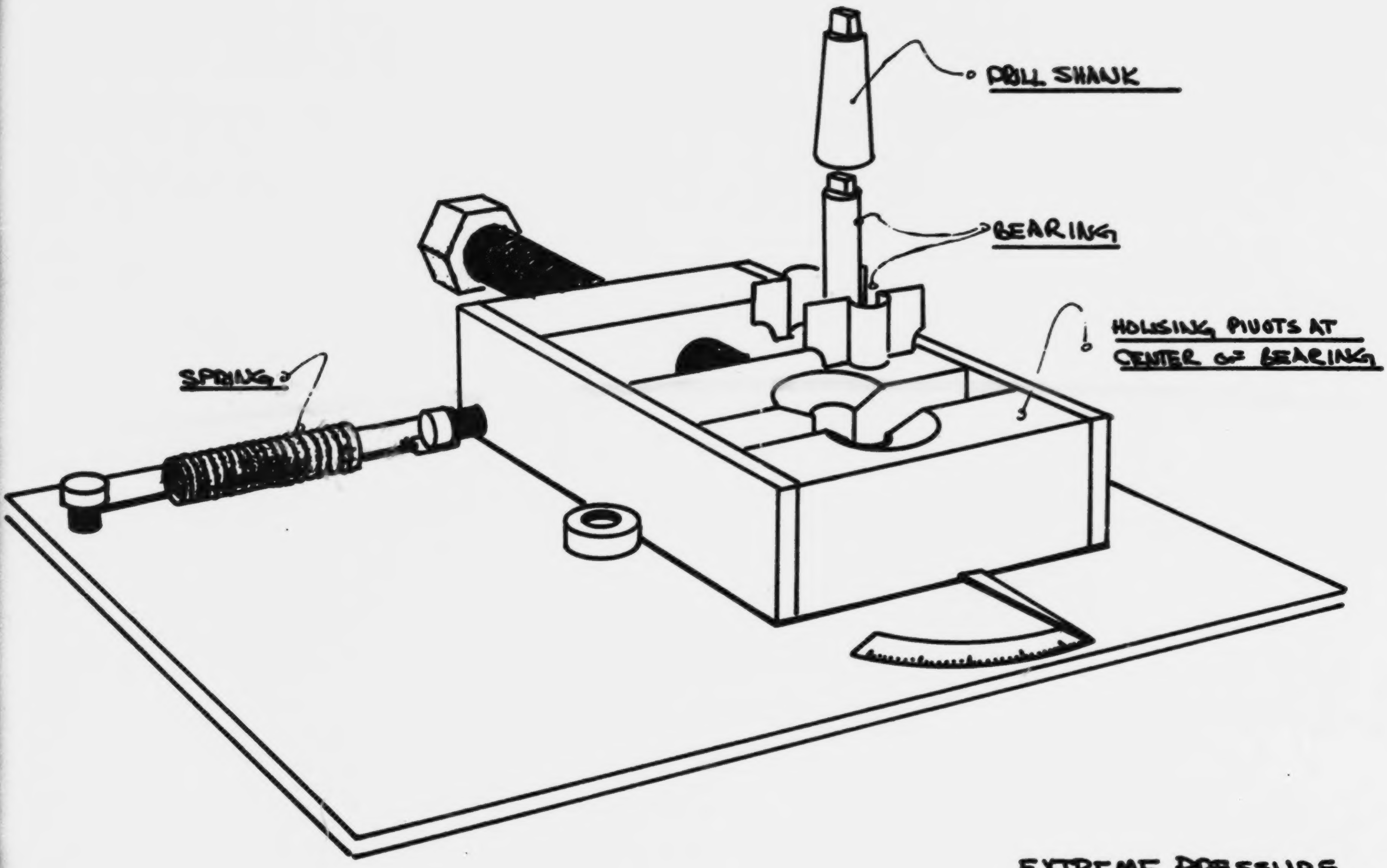
COMPOSITE OF CAR MANUFACTURERS' RECOMMENDATIONS

MINIMUM AIR TEMPERATURES	SAE VISCOSITY NUMBER								
	30	20	20W	10W	5W	20W 40	10W 30	10W 20	5W 10
32°F	X	X	X			X	X	X	
10°F			X	X			X	X	
0°F				X			X	X	
-10°F				X	X		X		X
BELOW -10°F					X				X

d

TABLE 2
SAE VISCOSITY CLASSIFICATION

SAE VISCOSITY NUMBER	SAYBOLT UNIVERSAL SECONDS			
	AT 0° F		AT 210° F	
	MIN	MAX	MIN	MAX
5W	—	4,000	—	—
10W	6,000	12,000	—	—
20W	12,000	48,000	—	—
20	—	—	45	58
30	—	—	58	70
40	—	—	70	85
50	—	—	85	110


DRILL SHANK
BEARING
HOUSING PIVOTS AT
CENTER OF BEARING
SPRING

EXTREME PRESSURE
LUBRICANT TESTER
BY F. DEMCHUCK

TORQUE

LOAD

500						22	
450			25			20	
400		22	22	22		16	18
350	18	18	18	19		15	17
300	16	16	16	16	12	14	16
250	13	12	12	13	10	12	15
200	10	10	10	11	8	10	14
150	7	7	8	8	4	7	10
100	5	4	5	5	1	5	5
	10	20	30	10-30	STP	30 STP	10-30 STP 2,000

TEMPERATURE

300	5.2	5.8	6	6.4	6.8	6.2	6.6	6.8	6.4
250	5.4	6	6.4	6.6	7	6.4	7	7	6.8
200	6.2	6.2	6.8	7	7.2	6.6	7.4	7.4	7.2
150	6.4	7	7.8	8	9	7	8.4	9	7.6
100	7.2	7.8	9.8	10.4	14	8	12.4	13	9.2
ROOM	8.6	10.2	11.4	13	22	9.8	18	21	11.8
25	30	1 MIN 10	2 MIN	2 MIN 45		52			
	10	20	30	40	50	10-30	20 STP	30 STP	10-30 STP 2,000

VISCOSITY

TEXTILES

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL STUDIES

PRESENTED BY: Hugh Barden
Hunt Junior High School
Tacoma, Washington

INSTRUCTIONAL LEVEL: Junior High

TITLE: Textiles

PRESENTATION TIME: One week & up

INTRODUCTION:

Textiles are to be studied from the understanding of materials approach, not the weaving or project approach. Student activities will consist of determining the chemical and physical properties of textiles. Textiles which are to be found in the students environment such as asbestos, cotton, nylon, dacron, rayon, silk, and wool will be used because of each fibers distinct chemical reaction to the more common laboratory reagents.

As textiles have been highly developed for many years, the textile industry has maintained a plateau. New fiber forms have been developed, but most have been developed to better meet an ever present need or in time of shortage to make a substitute - for example, nylon to replace the loss of silk during World War Two.

Space travel is requiring the textile industry to meet new demands created by man's meeting different environments. Development and research will have to deal with both fiber and fabrication to meet the demands of each new interplanetary environment as it is discovered. Students studying present textiles and environments will have a better base for development of textiles for the space age interplanetary environments.

OBJECTIVES:

1. To develop student knowledge of the different fibers in his environment
2. To develop student knowledge of how different fibers are affected by different environments
3. To develop student knowledge of how different fibers vary in strength
4. To develop student knowledge of simple chemical tests to determine one fiber from another
5. To develop student knowledge of the proper handling of corrosive chemicals
6. To develop student knowledge of the use of microscope for identification of fibers

INTERRELATION WITH OTHER SUBJECTS:

UNIT SUBJECT AREA: Textiles

INTERRELATION WITH OTHER SUBJECTS:

Can be included with plastics, transportation or upholstery laboratory. Textile studies will complement the studies of chemistry, physics, and industrial arts when the important questions of how and why are the objectives of the program.

USE IN INDUSTRY:

In order to exist, every industry must serve its customers. The textiles industry is one of man's oldest and largest industries. To maintain itself, the industry cannot allow its products to fail to satisfy its customers. Thus the textiles industry has grown from the household system to an industrial complex employing many people - with quality control to assure the production of the best fabric possible.

Fiber buyers constitute the first step in the process of quality control. Cotton alone has 13 separate grades, wood has 7 grades. The buyers have to use their judgement in selecting and buying for the textile companies they represent. After the buyers, the blenders job is to combine all the various kinds of fibers together to give the consumer the qualities to satisfy his fabric needs - as determined by the chemist and physicist.

The dying of fibers can take place after the yarn is spun, or after the fiber is woven, depending upon the characteristics of the fiber to be dyed. Synthetic fibers often require that a pigment be included in the original chemical mixing as a dye at a later time would not be absorbed into the fiber. At times resins are also used in such cases to adhere pigments to the outside of synthetic fibers. Natural fibers can be dyed in a number of different ways based on the absorption and on the chemical change brought about to color by actual change in the chemical composition of the fiber reacting with the dye.

Weaving the physical combining of yarns into cloth. There are nine fundamental weaves which may be chosen to give a desired texture, appearance, or strength to a cloth to meet certain physical needs.

MATERIALS AND EQUIPMENT:

microscope
12 - 100 ml beakers

reagents:
- Nitric Acid
- NaClO
- Acetone
- HCL
- NaOH
- H_2SO_4
- Methylene Chloride

thread and fabric samples of the following:
- Asbestos
- Cotton
- Nylon
- Orlon
- Rayon
- Silk

spring scales - 0-48 oz, 0-10 lb, 0-100 lb
aircraft fabric tester
4 test tube racks
4 dozen test tubes
12 beakers - 500 ml
glass tubing

EDUCATIONAL MEDIA:
- transparencies - attached
- educational films (see appendix for ordering information)
  - COMPOSITION AND PROPERTIES OF PLASTICS
  - DU PONT STORY
  - INTRODUCTION TO PLASTICS
  - MANUFACTURE OF PLASTICS
  - NEW WORLD OF CHEMISTRY
  - PHYSICAL CHEMISTRY OF POLYMERS
  - PLASTICS, INDUSTRIAL PROCESSES AND PRODUCTS
  - PROSPECTS FOR PLASTICS
  - WHAT CAN THE MATTER BE?

UTILIZATION IN THE TEACHING LEARNING ENVIRONMENT:

SAFETY:
1. Pour reagent into water slowly
2. Work by the sink
3. Work only with friend close by
4. Work in assigned area only

PRESENTATION:

I. Early basis for selection of textiles: climate of environment at that time, sources of fiber available, skills required to obtain fibers. Have students make a length of yarn from a wad of cotton; have students unravel cloth and thread to separate fibers.

II. Present basis for selection of fabrics: environment where available and needed; source of fibers. Discuss textiles worn by students, source, conditions of treatment that they must withstand. Test fabric samples on abrasion, water permeability, and tensile tester.

III. Importance of textiles today
   A. Home: wall coverings, curtains, furniture, finishes. Discuss: fire, stain, fade and abrasion resistance. Demonstration and experiments as to resistances.
   B. Space: clothes, transportable living quarters. Discuss: protection from inside & outside environment of space ship - temperature control, blood pressure control, protection from: suns rays, cold, heat.
   C. Industry: reinforcement: Discuss combining physical properties: flexible hoses (rubber/ cotton-rubber), glass fibers in power transmission belts, nylon fabric in tires. protection: heat & radiation shield, electric shock. Demo. tensile and burst strength tester. student tests of reinforced & non-reinforced hose, cotton & asbestos gloves for heat protection, aluminum backed plastic for reaction of heat radiation on each side, and bursting strength of cloth.

IV. Properties of textiles: thermoset & thermoplastic: Discuss: plastics that burn without melting, plastics that melt, then burn. Activities: teacher demo., then student experiments with melting point and firepoint testers. Trans. 1,2 structure of matter: atomic, molecular. discuss joining. work with models. Students make nylon thread. trans. 3, 6, 7, 8, 9, 10, 11. microscopic examination of fiber: discuss use of microscope, physical shape of fibers. chemical examination of fibers: trans. - fiber structures; proper handling and use of reagents, reactions to be observed, safety. teacher demo & student experiments in pairs.

EVALUATION AND OBSERVATION:

STUDENT PERFORMANCE:

Judged on instructors observation, basis of work sheet, and written test performance.

UNIT EVALUATION:

Do students know how to:

1. use the microscope
2. pour reagents
3. define atoms
4. define molecules
5. define the difference molecular structure has on a material
6. test and select fibers for use in fabric

DEFINITION OF TERMS:

1. carding: the process of untangling and partially straightening fibers by passing them between two closely spaced surfaces which are moving at different speeds, and at least one of which is covered with sharp points, thus converting a tangled mass of fibers to a filmy web.
2. kink - place in the fabric where a slack strand has twisted on itself forming a loop in the yarn or cord
3. rows - the average number of tufts or loops per inch counted in the warpwise direction
4. singling - the condition caused by the breaking of one or more strands in a plying operation with resulting unevenness in the finished product
5. thread - fibrous material spun out to considerable length; especially such as cord composed of two or more filaments twisted together.

REFERENCES:

STUDENT:

Modern Plastics Encyclopedia, Vol. 43, No. 1A, 1965.
Plastics Reference Issue, Machine Design, Vol 38, No. 14.
Phillips Petroleum Co., Glossary of Plastic Terms
Swanson, Robert. Plastics Technology

TEACHER:

ASTM Standards on Plastics
ASTM Standard. Textile Materials, Fibers, Zippers, High Modulus Fibers
Kaswell, Ernest R. Wellington Sears Handbook of Industrial Textiles.

CHEMICAL METHODS FOR ANALYSIS OF FIBER MIXTURES

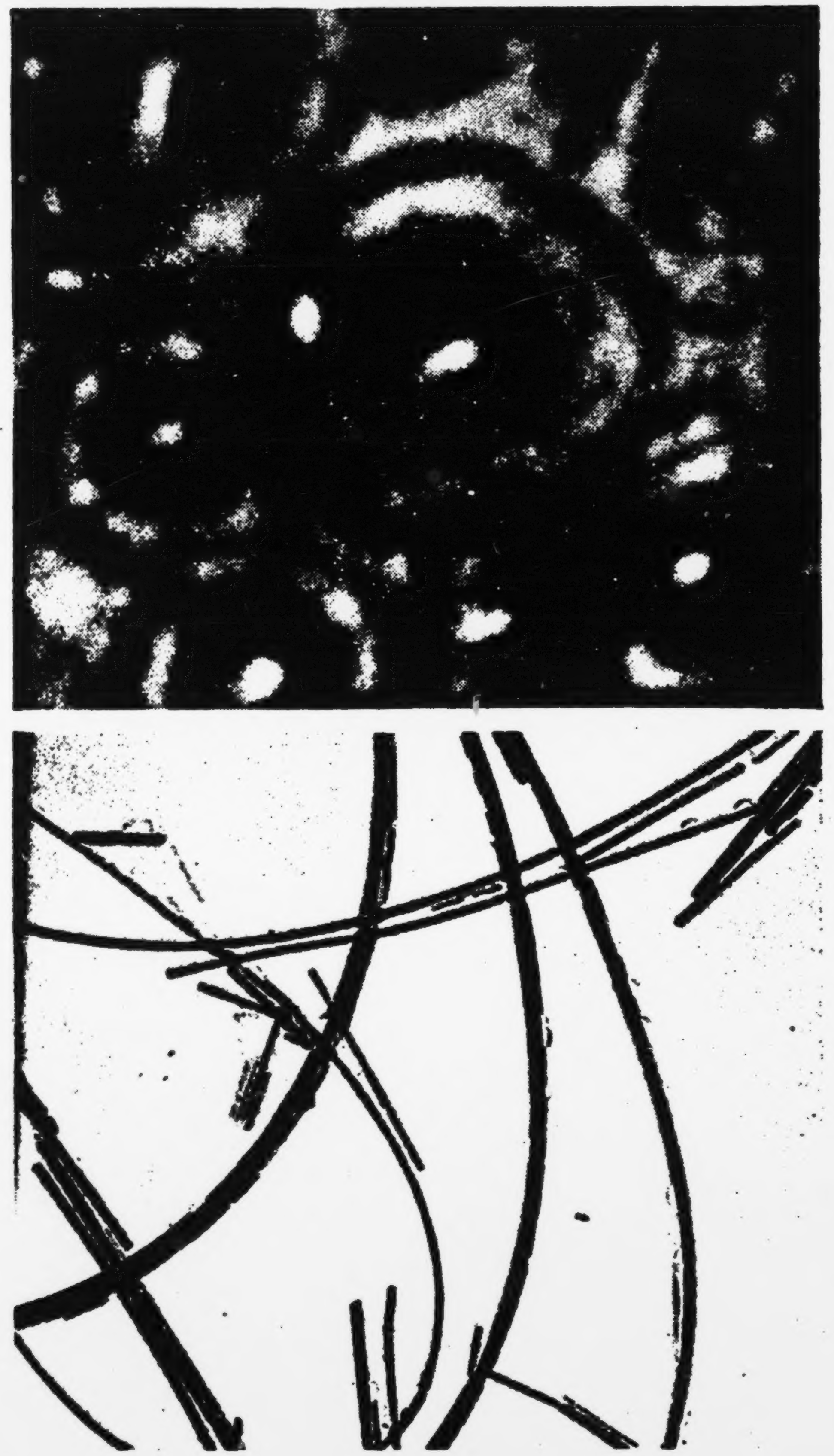
	WOOL	TUSSAH SILK	SILK	RAYON	NYLON	DACRON
COTTON	7,5		4	4	3	5
DACRON	6		4	4	3	
NYLON	3		7	3		
RAYON	7,5	7	7	3		
SILK	5					
TUSSAH SILK	5					

3 - .28% Hydrochloric Acid
4 - 59.5% Sulfuric Acid
5 70% Sodium Hypochlorite
6 Sodium Hypochlorite
7 5% Sodium Hydroxide

QUALITATIVE ANALYSIS OF GENERIC CLASSES

GENERIC CLASS	FIBER REMOVED	TEMP.	REAGENT
polyamide	nylon	room	20% hydrochloric acid
protein	silk, wool	room	sodium hypochlorite (5% available chlorine) If silk is suspected, remove with 37% hydorchloric acid
cellulosic	cotton, flax, rayon	room	75% sulfuric acid. separate rayon with 37% hydrochloric acid. cotton & flax can be distinguished by microscopic appearance
polyester	dacron, kodel, rilsan	200°F	m-Cresol

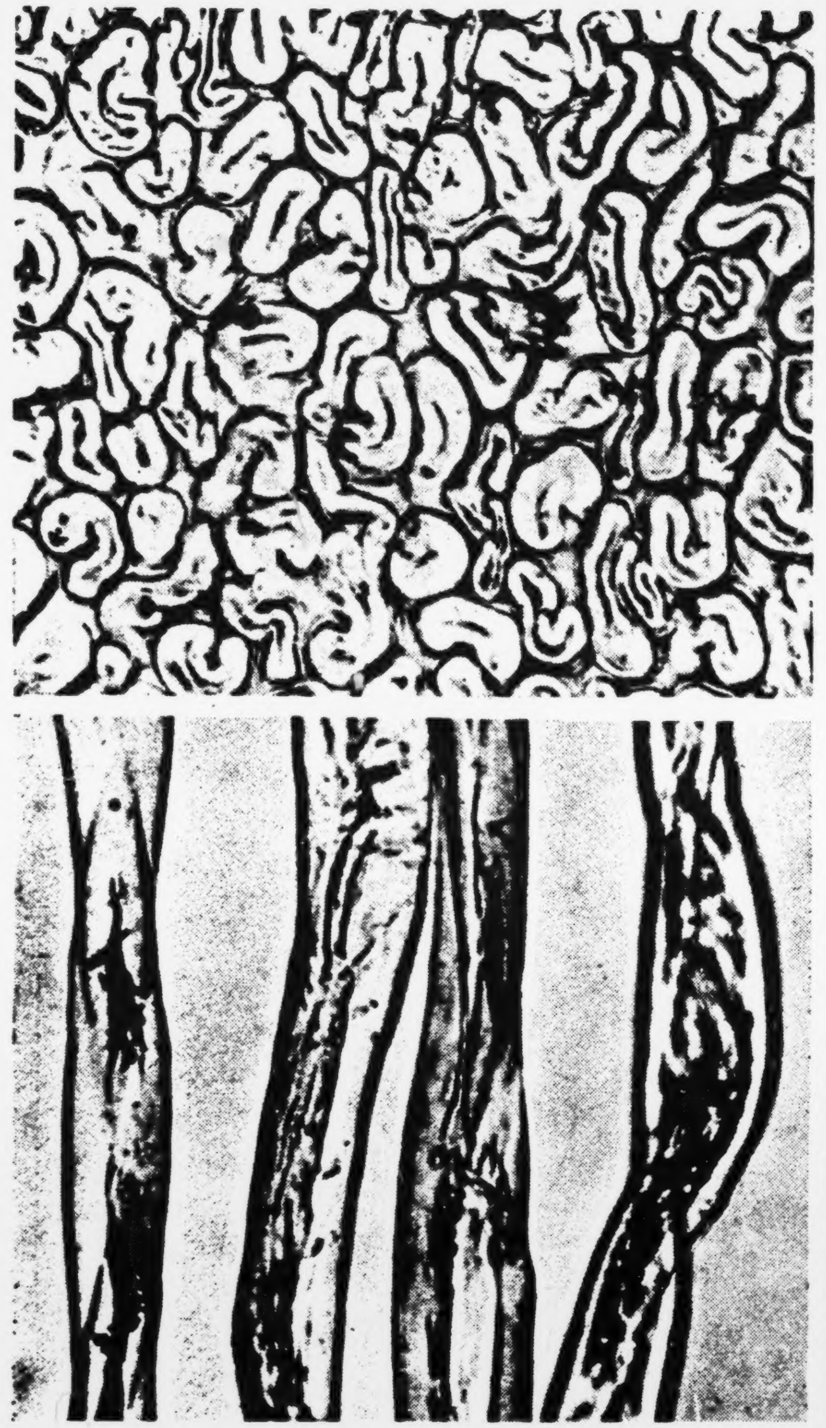
(*a*) Cross-Sectional View (×990,000)



(*b*) Longitudinal View (×25,000)

Fig. 18.—Asbestos Fibers.

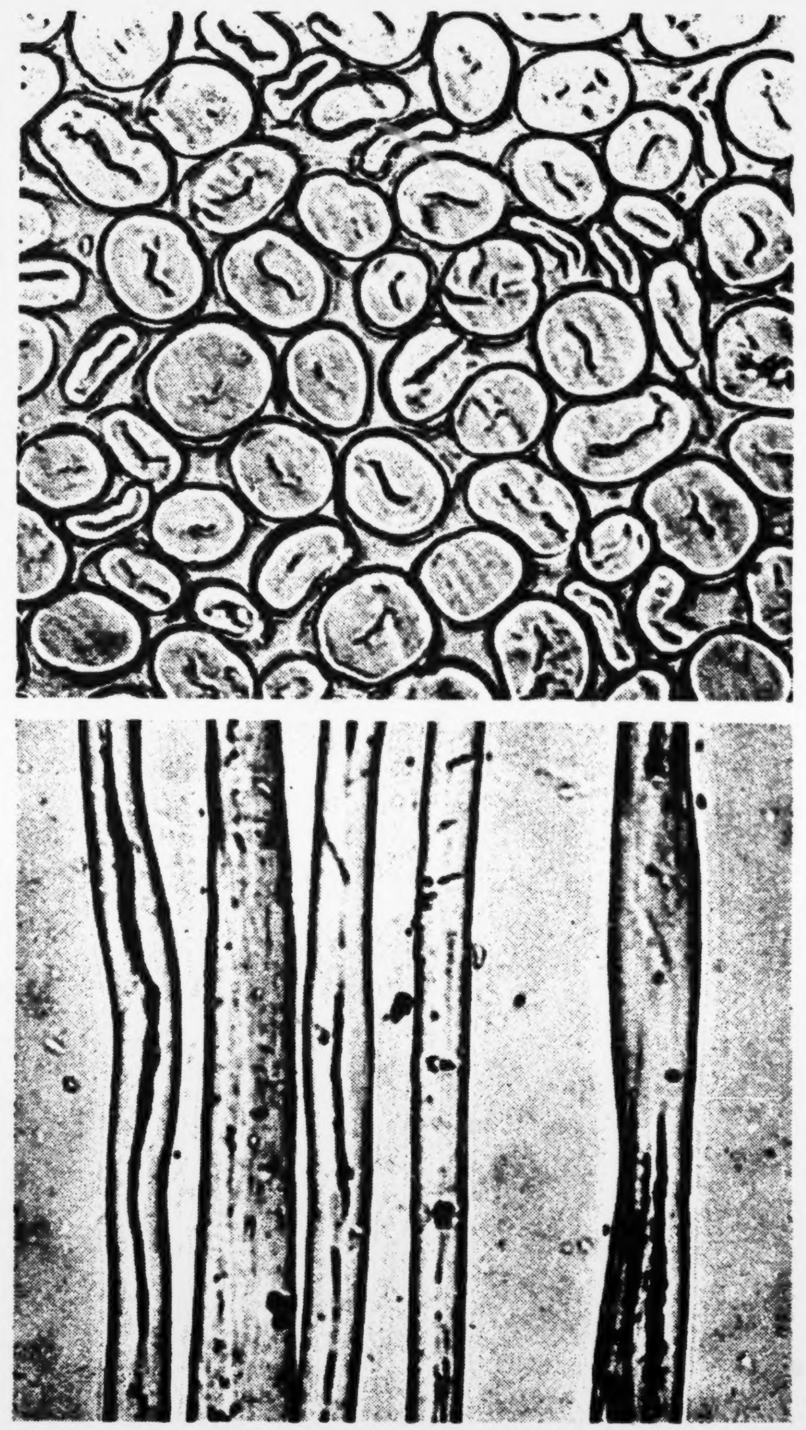
(*a*) Cross-Sectional View (×500)



(*b*) Longitudinal View (×500)

Fig. 1.—Cotton Fibers, Not Mercerized.

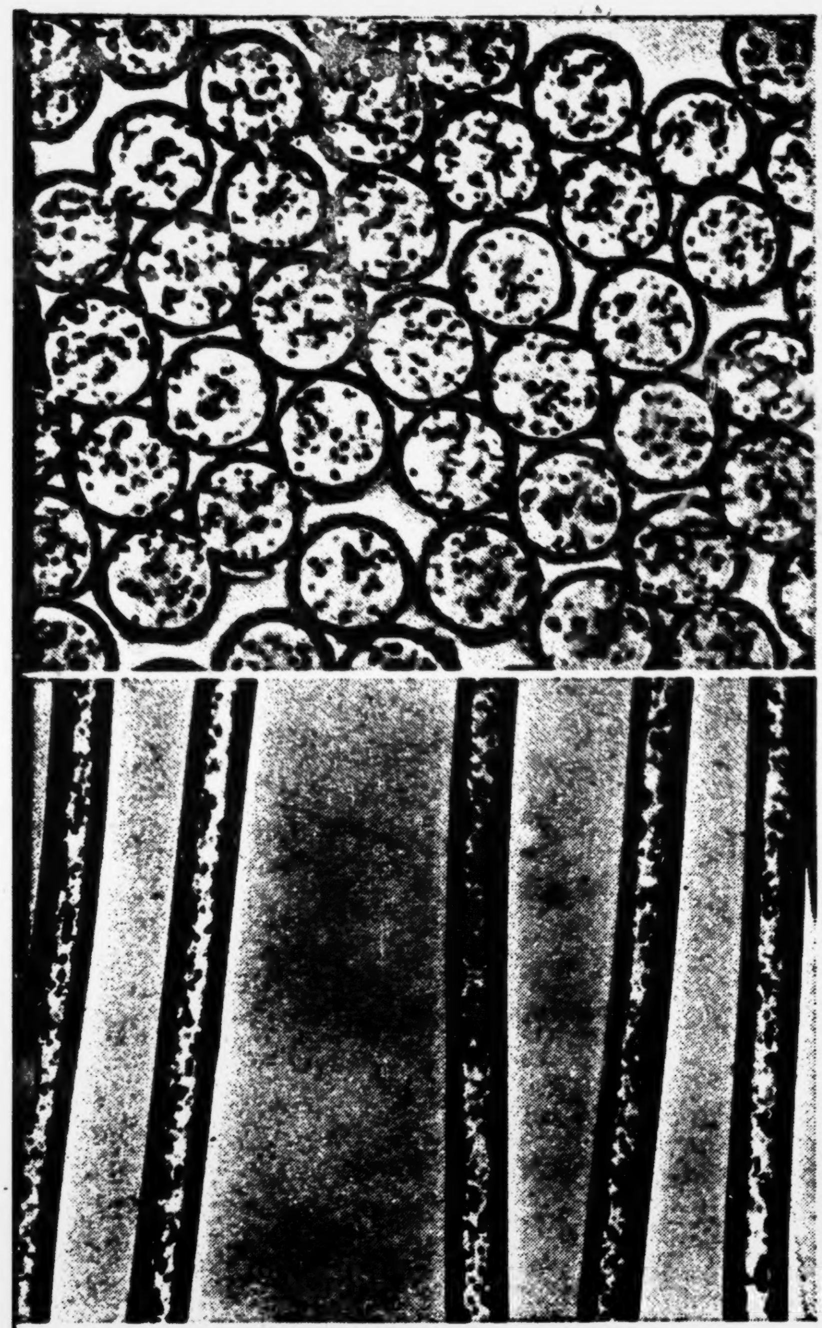
(*a*) Cross-Sectional View (×500)



(*b*) Longitudinal View (×500)

Fig. 2.—Cotton Fibers, Mercerized.

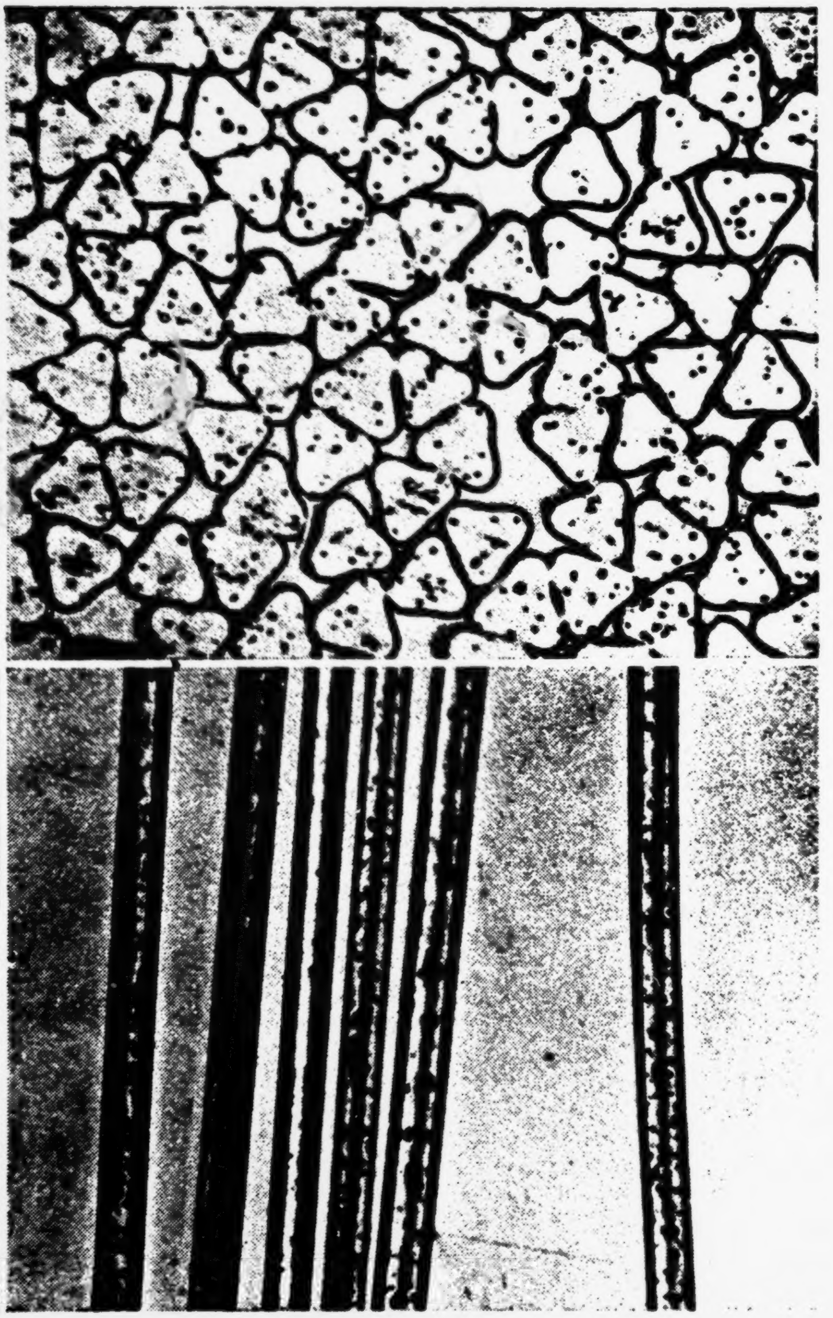
(*a*) Cross-Sectional View (×500)



(*b*) Longitudinal View (×250)

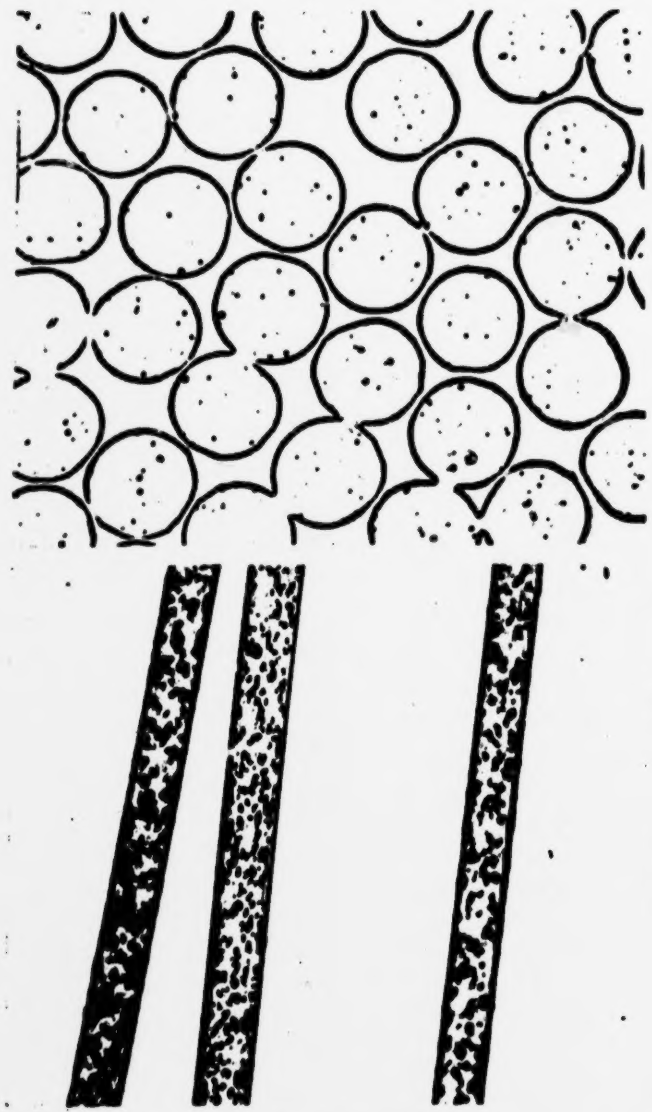
Fig. 34.—Regular Polyester (Melt Spun) Fibers, 3.0 Denier (0.33 Tex) per Filament, Semi-Dull. Typical of Dacron Regular, Dacron Type 64, Kodel, Vycron, Fortrel, and Several Foreign Fibers.

(*a*) Cross-Sectional View (×500)



(*b*) Longitudinal View (×250)

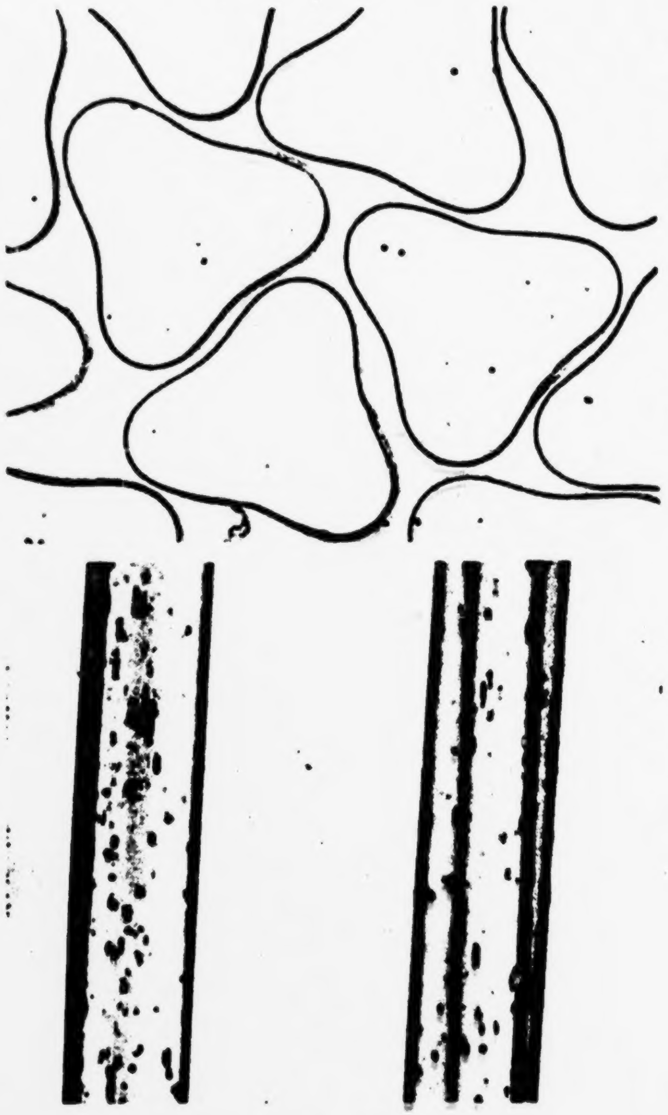
Fig. 35.—Low Modification Ratio Trilobal Polyester Fibers, 1.4 Denier (0.15 Tex) per Filament, Semi-Dull Luster. Typical of Dacron Type 62.



(a) Cross-Sectional View (×500)

(b) Longitudinal View (×250)

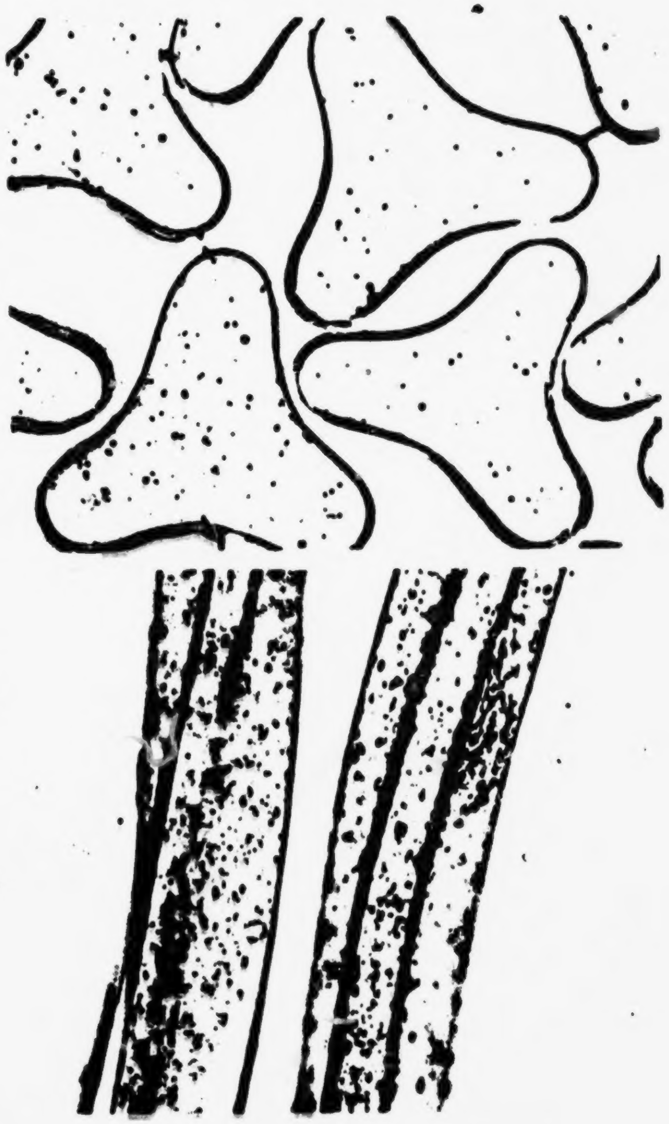
FIG. 28.—Regular Nylon (Melt Spun) Fibers, 3.1 Denier (0.34 Tex), Semi-Dull. Typical of Nylon 6-6, Nylon 6, and Nylon 11.



(a) Cross-Sectional View (×500)

(b) Longitudinal View (×250)

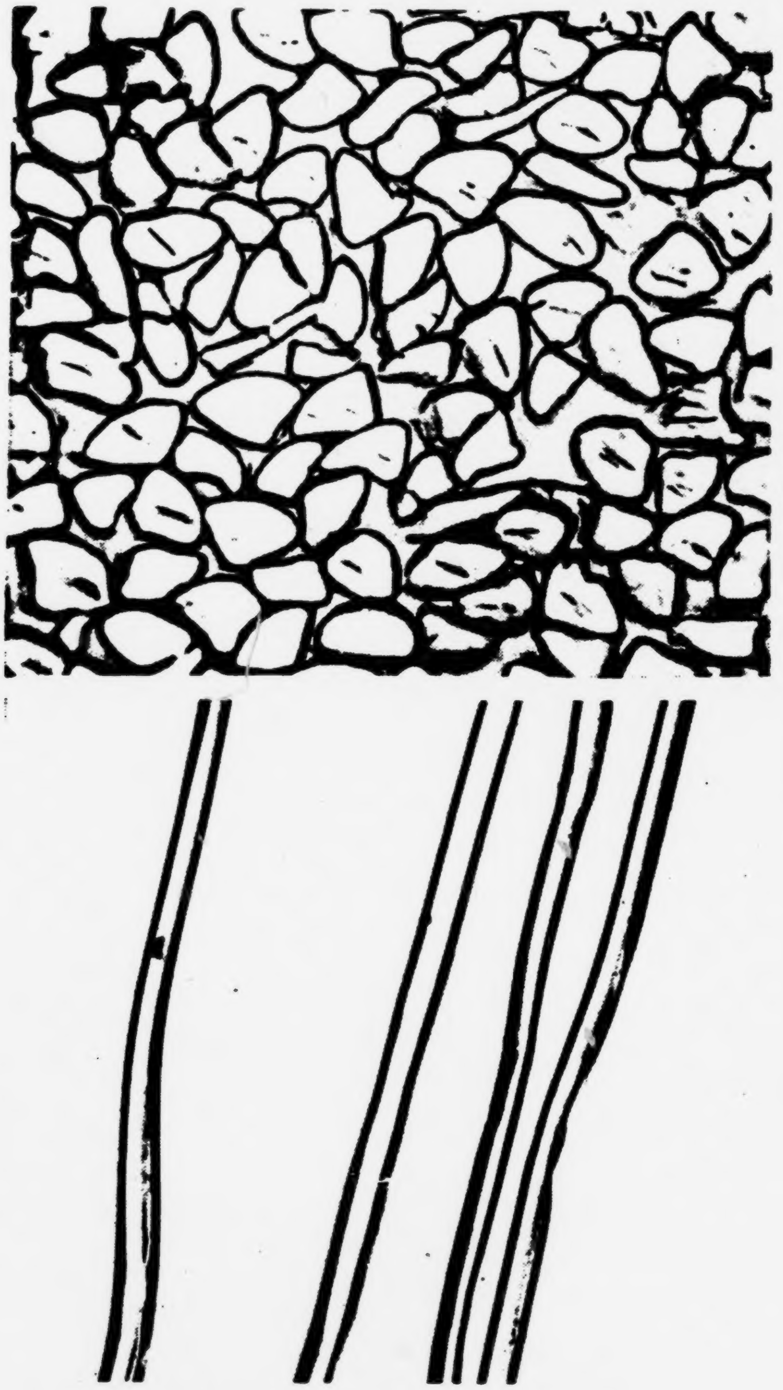
FIG. 29.—Low Modification Ratio Trilobal Nylon Fibers, 15 Denier (1.65 Tex) per Filament, Bright Luster. Typical of Antron.



(a) Cross-Sectional View (×500)

(b) Longitudinal View (×250)

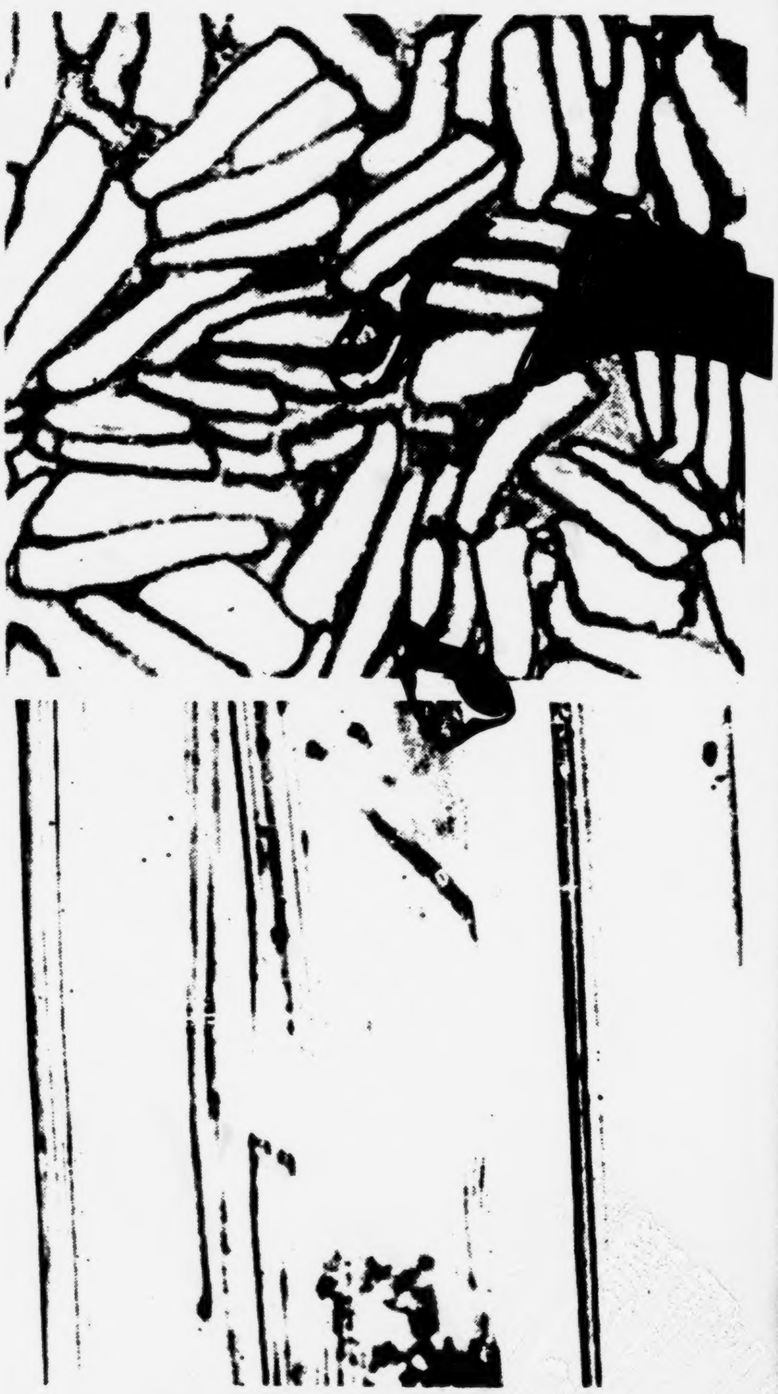
FIG. 30.—High Modification Ratio Trilobal Nylon Fibers, 18 Denier (1.98 Tex) per Filament, Semi-Dull. Typical of Du Pont 501.



(*a*) Cross-Sectional View (×500)

(*b*) Longitudinal View (×250)

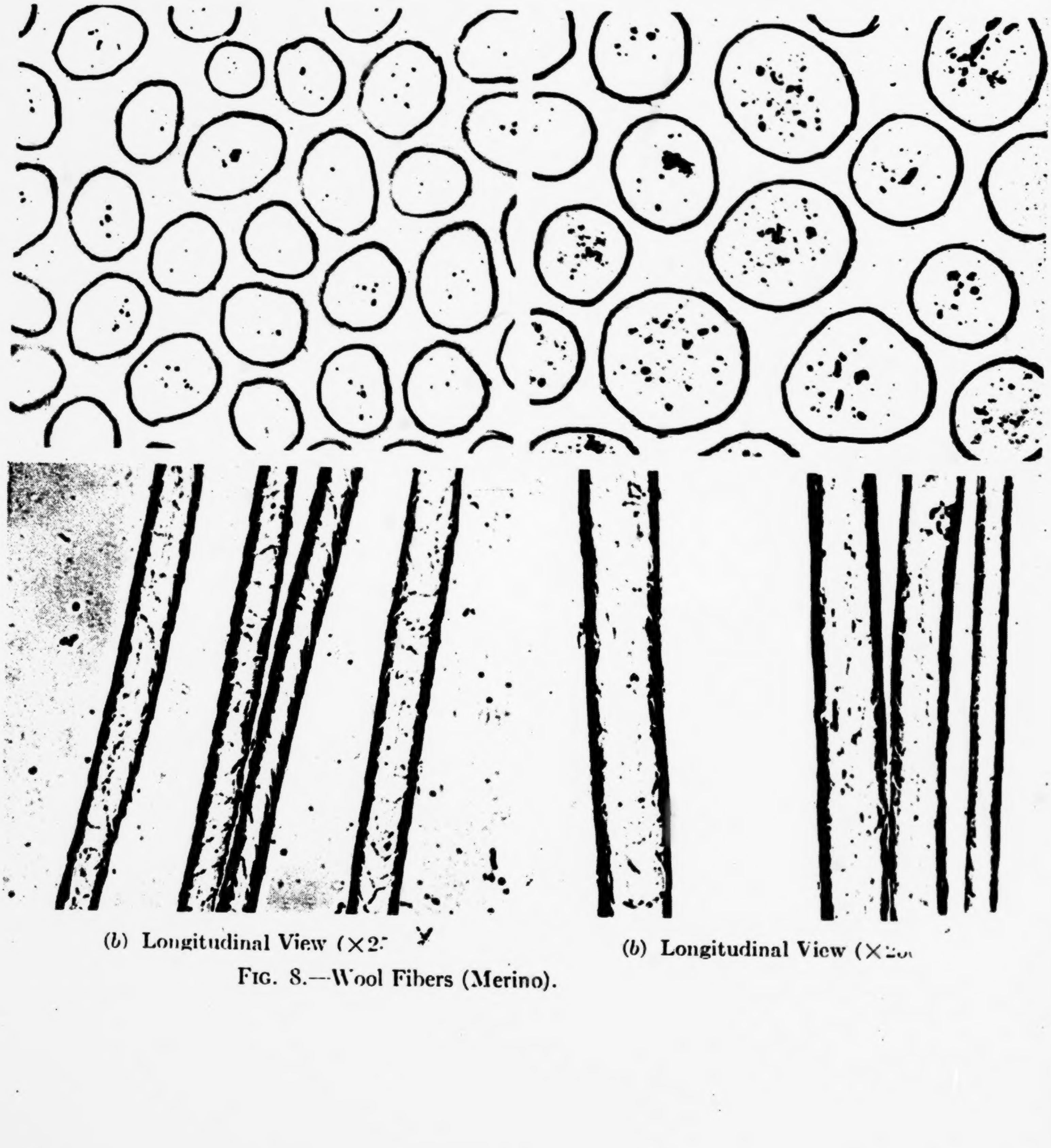
Fig. 16.—Silk Fibers.



(*a*) Cross-Sectional View (×500.

(*b*) Longitudinal View (×500

Fig. 17.—Silk Tussah Fibers.



(a) Cross Sectional View (×500)

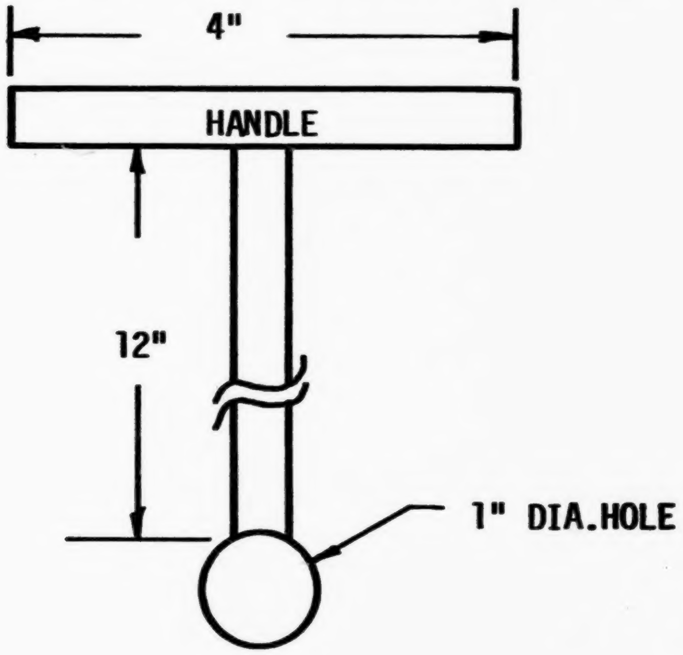
(a) Cross-Sectional View (×500)

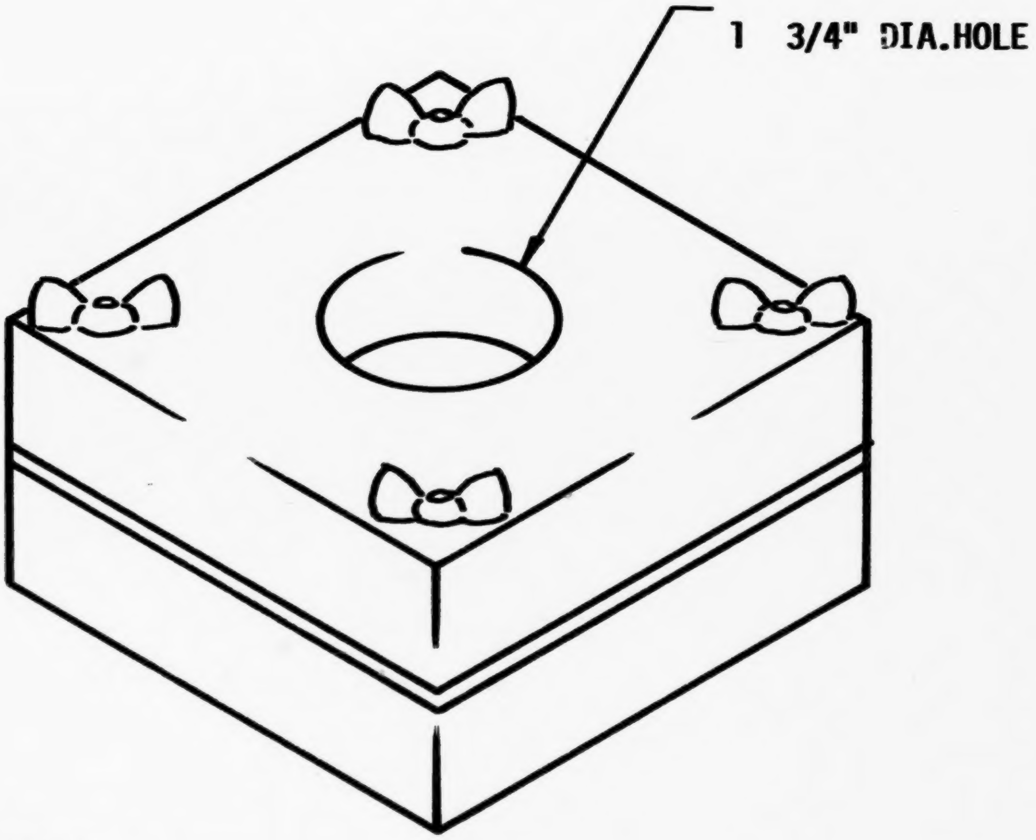
(b) Longitudinal View (×2

(b) Longitudinal View (×2

FIG. 8.—Wool Fibers (Merino).

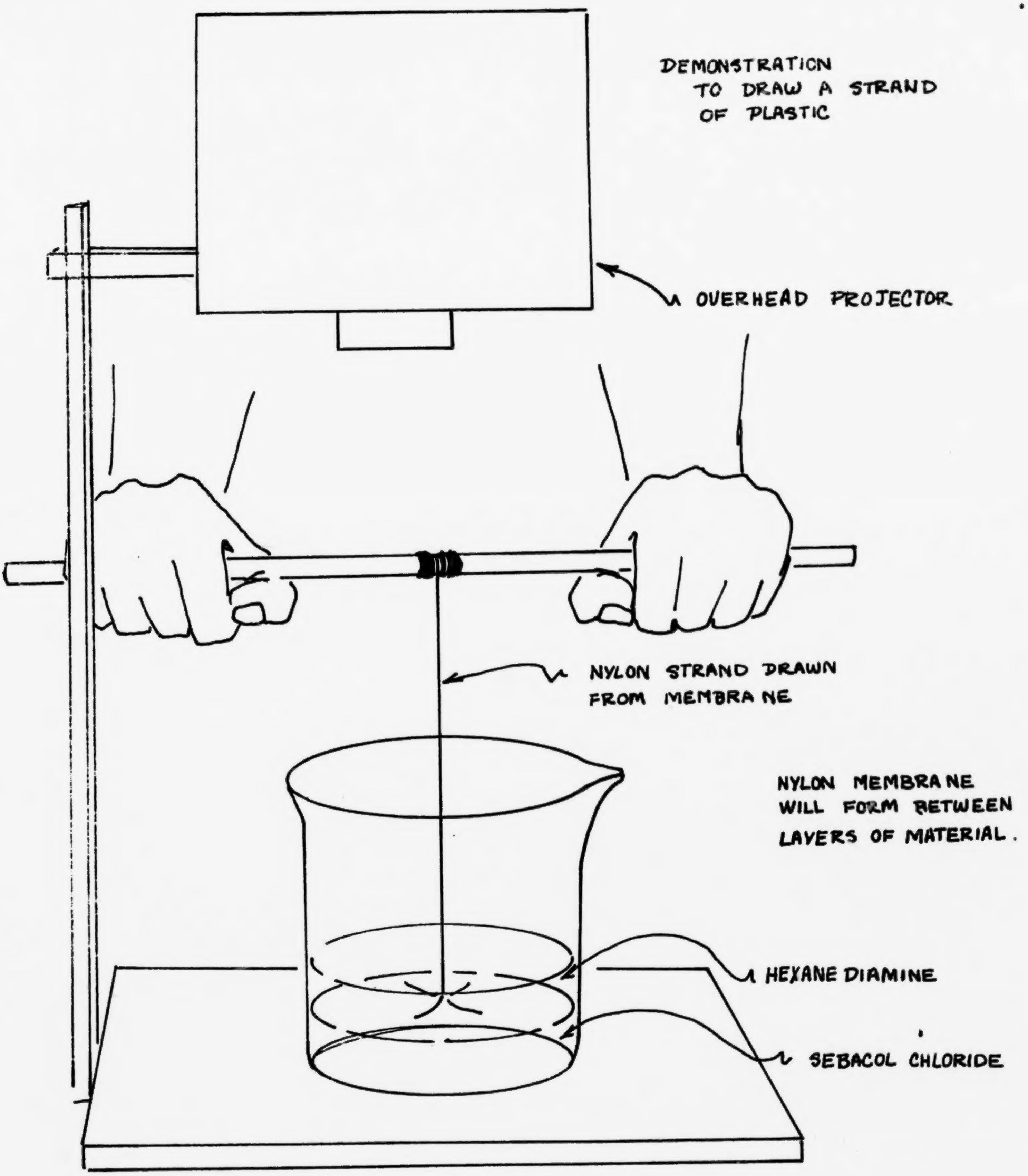
BURST STRENGTH TESTING DEVICE (TESTILES)


4"
HANDLE
12"
1" DIA.HOLE


1 3/4" DIA.HOLE

MATERIALS:

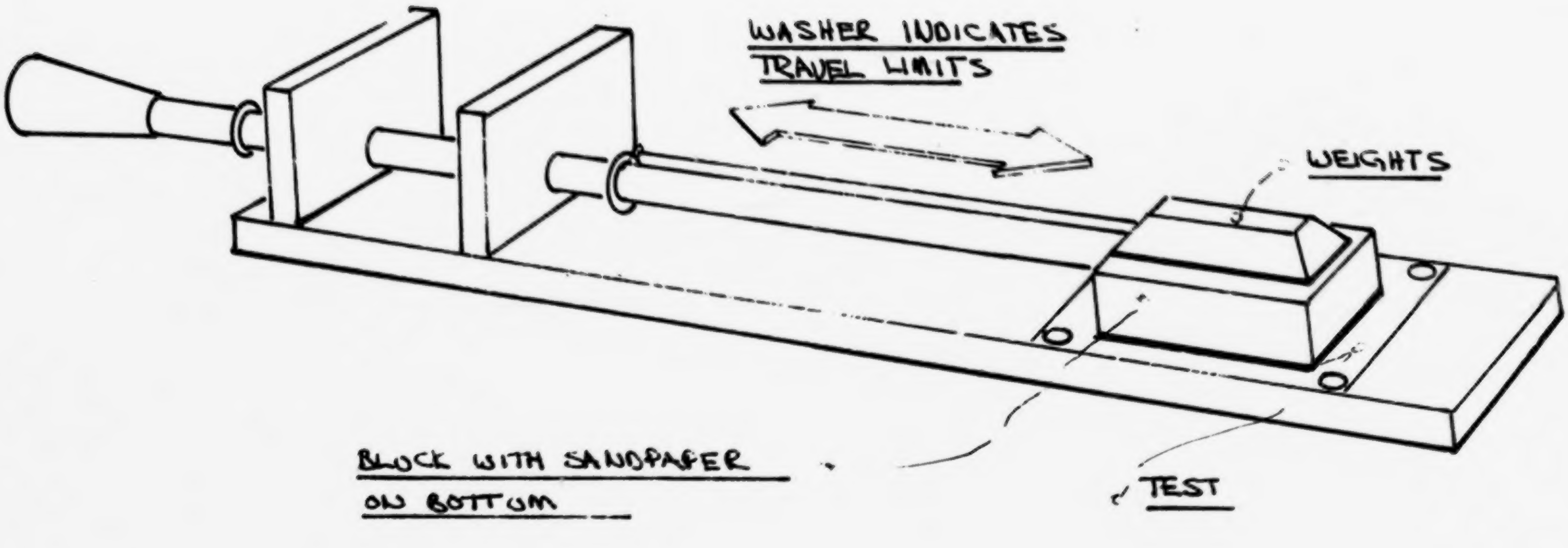
(1) 2 - 2" x 4" x 4" block of maple
(2) 4 - 1/4" bolts with wing nuts
(3) 1 - 1/2" square rod 16" long
(4) 1 - 1" dia steel ball
(5) sample sizes 4" x 4"



DEMONSTRATION
TO DRAW A STRAND
OF PLASTIC

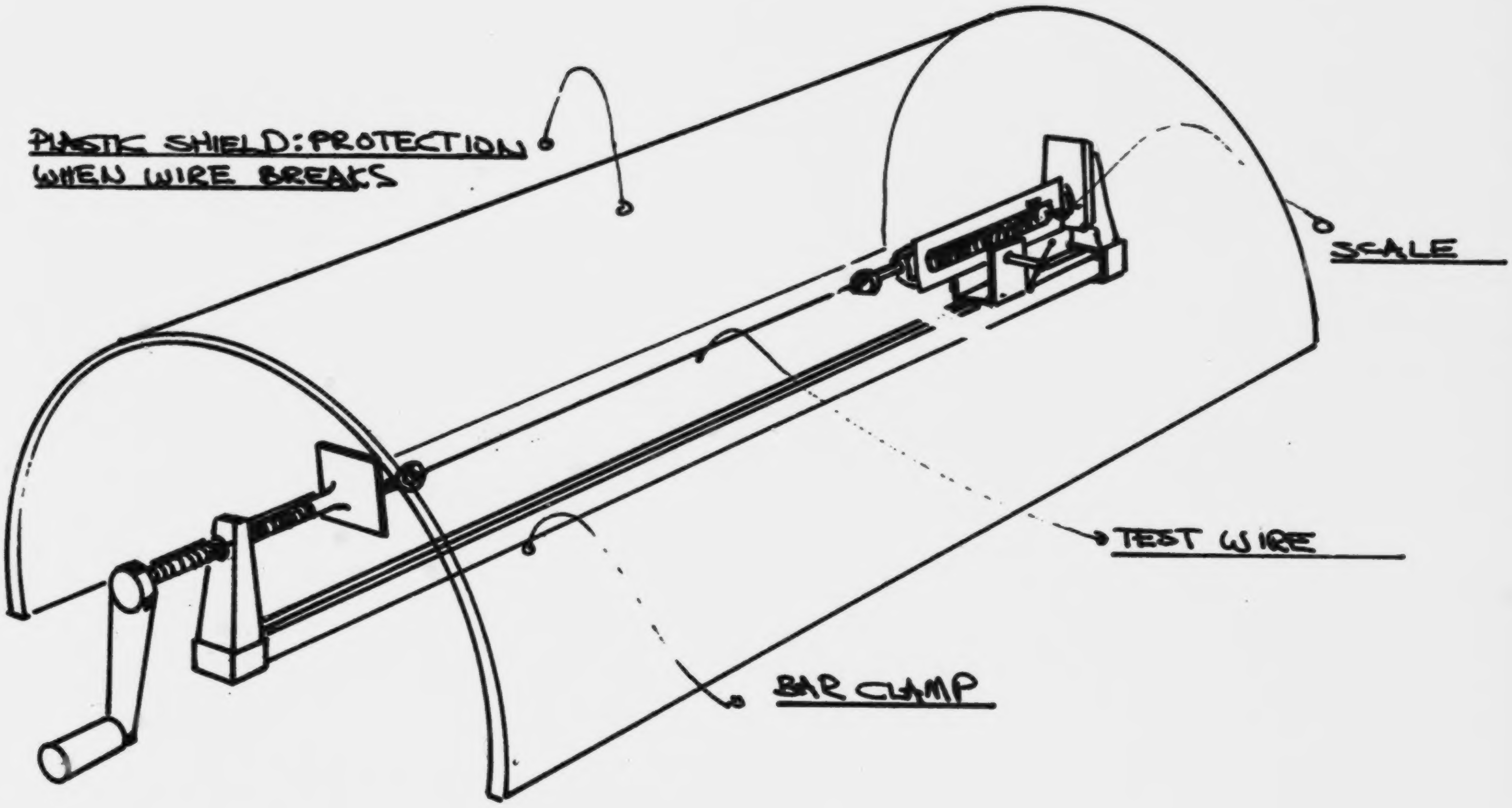
OVERHEAD PROJECTOR
NYLON STRAND DRAWN FROM MEMBRANE
HEXANE DIAMINE
SEBACOL CHLORIDE

NYLON MEMBRANE
WILL FORM BETWEEN
LAYERS OF MATERIAL.

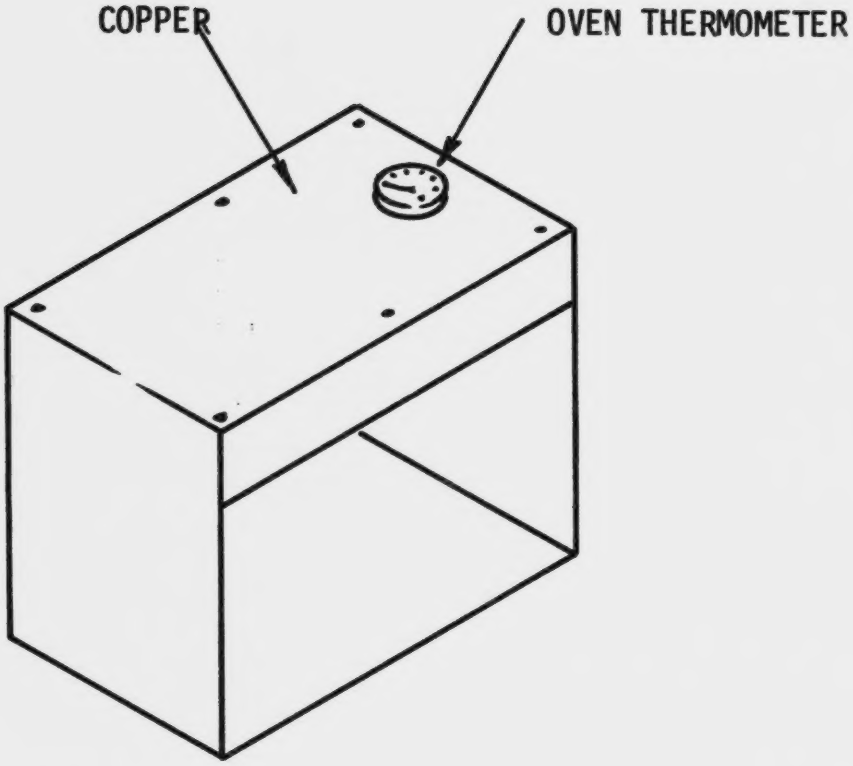

WASHER INDICATES TRAVEL LIMITS
WEIGHTS
BLOCK WITH SANDPAPER ON BOTTOM
TEST

ABRASION TESTER FOR CLOTH

TENSILE STRENGTH OF THREAD OR CLOTH


PLASTIC SHIELD: PROTECTION WHEN WIRE BREAKS
SCALE
TEST WIRE
BAR CLAMP

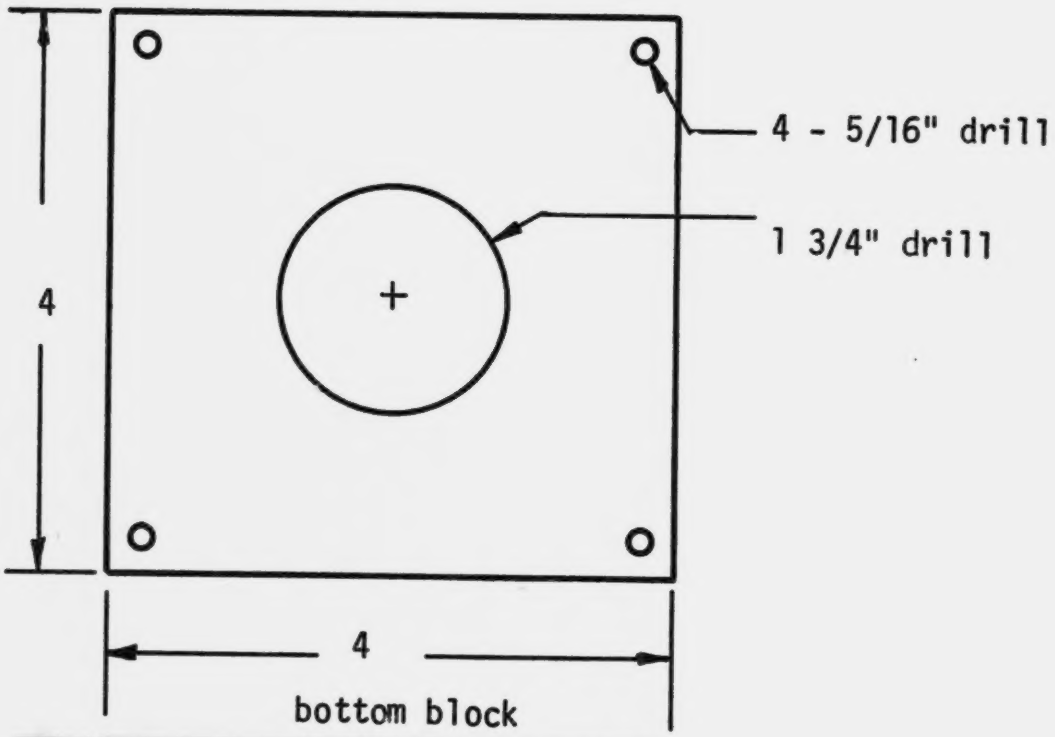
NOTE: FOR TESTING-
CLAMP CLOTH IN
WOODEN BLOCKS AT
EACH END OF SAMPLE
AND PLACE PULL ON
WOODEN BLOCKS.



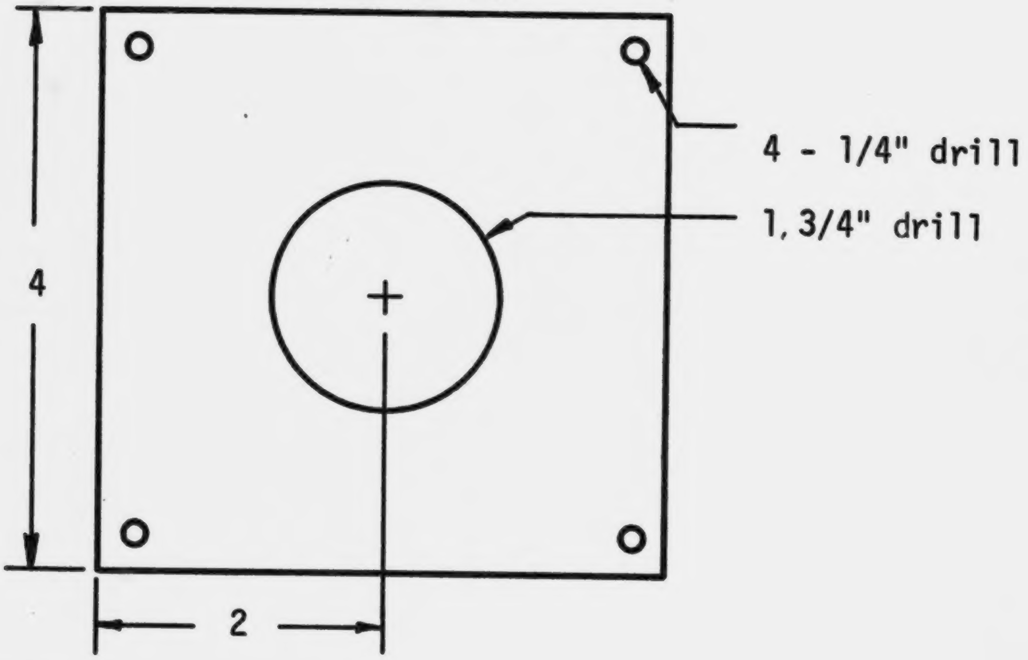
MELTING AND FIRE POINT TESTER (TEXTILE)

DESCRIPTION: metal box 4"wide x 12" high x 8" long. ends, bottom, top and side closed. top made of copper the mest made of steel and riveted together. oven thermometer used on top. bunsen burner is heat source.

top block



bottom block



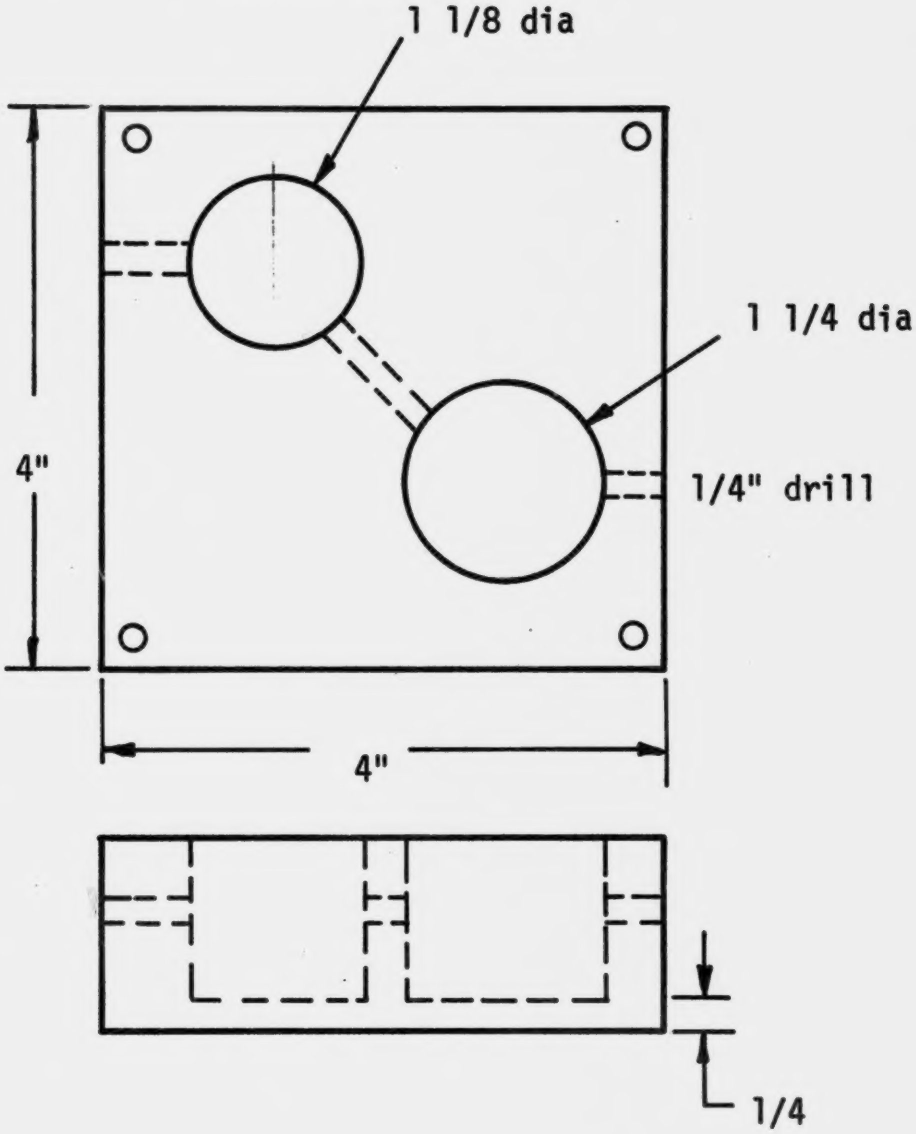
BURST STRENGTH:
construction of block

1. cut block to size
2. drill 1 3/4" hole in center
3. drill 1/4" hole in corners of both blocks
4. counterbore bottom of bottom block for bolt heads
5. ream 1/4" holes in top block to 5/16"
6. assemble and weight assembled block and weight to even pound.

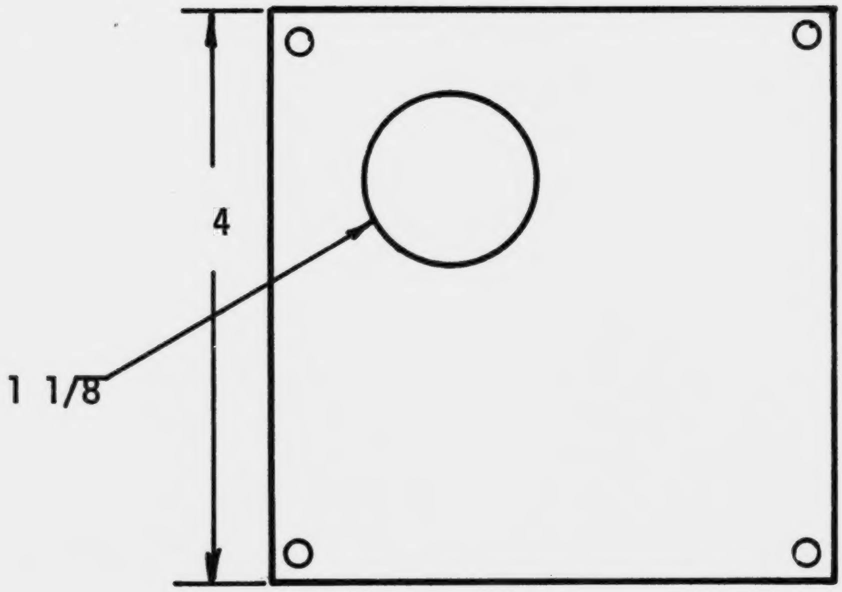
construction of rod

1. cut 16" length of 1/2 sqiare rpd omtp 4" amd 10" nieces and weld in "T" shape
2. weld 1" steel ball to end of shaft opposite handle

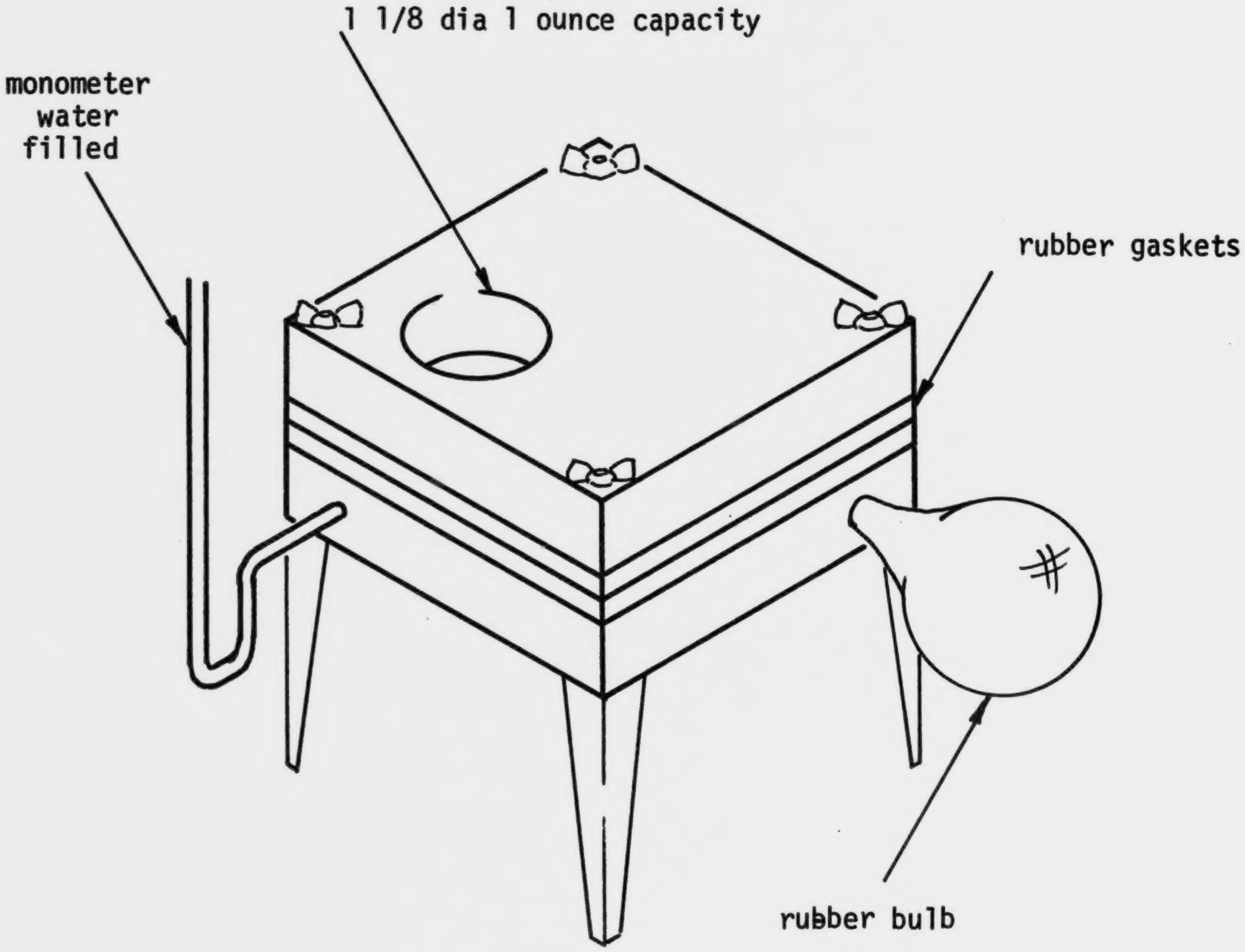
BOTTOM BLOCK


1 1/8 dia
1 1/4 dia
4"
1/4" drill
4"
1/4

TOP BLOCK



rubber cut to shape of top block and cemented to top of bottom block and bottom of top block for gasket.


1 1/8 dia 1 ounce capacity
monometer water filled
rubber gaskets
rubber bulb

materials for tester construction

1. 4---legs of sheet metal
2. 2---block of 2" x 4" x 4" maple
3. 1---piece of glass tubing 24" long
4. 1---rubber bulb for pressure
5. 4--- 1/4" bolts and wing nuts
6. 2 ---pieces of rubber (innertube) approximately 1/8" x 4" x 4"
7. rubber cenent to fasten rubber gasket to blocks

SAN JOSE STATE COLLEGE
INDUSTRIAL STUDIES DEPARTMENT
1968 NDEA INSTITUTE IN INDUSTRIAL STUDIES

PRESENTED BY: Jerald Schoenike
Sheboygan Public Schools
Sheboygan, Wisconsin

Al Slowe
North Attleboro High School
North Attleboro, Massachusetts

William Velez
San Juan Educative Region
Rio Piedras, Puerto Rico

TITLE: The Future is Our Assignment

INTRODUCTION:

This material is designed to be presented to instructors of industrial arts, supervisors and administrators of industrial arts, and students studying industrial arts education.

OBJECTIVE:

To emphasis the importance of industrial arts teachers to change the method of instruction from project centered to a problem solving method in keeping pace with industrial technology.

SLIDE	NARRATIVE
1. Title	The Future is Our Assignment
2. Aware of changes	Industrial arts teachers, to be sure, are aware of some of the changes being proposed in industrial arts curriculum and organizational patterns.
3. American Industry	Several of the prominent new curriculum ideas are: The American Industry Program at Stout State University.
4. Industrial Arts Curriculum Project	The Industrial Arts Curriculum Project at Ohio State University.
5. San Jose State College	Industrial Materials Program at San Jose State College.
6. R & D in Industrial Arts	The Research and Development Program associated with the University of Maryland.
7. Realization of new approaches	Understanding the methodology of each of these programs is not important, as the realization that new approaches are being tried in industrial arts.

8. Industrial Arts Improvement	Each is reaching for the same objective; to serve our society in the most effective way possible through industrial arts instruction.
9. Rocket shot 10. Space vehicle	The growth of technical knowledge has changed the entire industrial organization.
11. Graphics press 12. Electrical Generating Plant 13. Construction Project 14. Bottling Plant	We can only glimpse at a few facets of industrial complexities.
15. Student	It is for this complex industrial society that we must prepare todays student.
16. Teacher and tech. books	Industrial arts course content has probably expanded more than other subjects....
17. Small business	and industry is changing so drastically from the small organization.....
18. Large industry	to large organizations....
19. Reading want ads 20. Job opening sign	that industrial arts can no longer afford to teach little but skills and information about a few industries if industrial arts is to meet its objectives.
21. Student understanding	Moreover, a thorough understanding of our industrial culture is essential to bridge the gap between the present and an increasingly complex future.
22. Industrial Arts-Industry	What does industrial arts need do in order to maintain parallelism to that of industry?
23. Industrial Arts shop 24. Industrial Arts shop	For many years, and still for that matter, industrial arts has been known as a class to make and fix things, by the student, parent, school administrators, and fellow teachers...rather than the understanding and application of problem solving techniques displayed by todays industry.
25. Student-Teacher-Project	Yes, industrial arts teachers are using problem solving but largely for the purpose of completing a project.
26. Change?	Several points have been mentioned thus far as to why instructional methods need to change in industrial arts....

27. Why?	but let us look at several other reasons WHY to promote problem solving in industrial arts.
28. Scientific principles	First, all industrial processes are based on application of scientific principles.
29. New concepts	Second, the time we have to teach the subject matter does not permit covering all the new concepts and changes occuring in industry.
30. Adapt to change	Third, the technical changes demand people with a greater ability to adapt himself to the changes in his work.
31. Skills for consumers	Fourth, students can apply learned skills and understandings toward constructive leisure time activities and as a consumer of industrial products.
32. Understanding of materials	And fifth, students will have a better understanding of physical, mechanical, and general environmental properties of materials to better understand industrial operations.
33. How?	How can you as a teacher incorporate some ideas into your present program? Following are several ideas that could easily be set-up in most industrial arts laboratories.
34. Viscosity equipment	Equipment needed to test and demonstrate viscosity of motor oils and temperature effects on them.
35. Student at refrigerator	A refrigerator can be used to reduce the liquids below room temperature.
36. Student working experiment	Students can determine the control factors of the lesson and follow the experiment through to completion.
37. Viscosity results	Students can develop charts to show the results of their tests and exploring.
38. Teacher sawing log	Sawing "green logs" in the classroom can provide many "whys" on moisture content of wood....
39. Mositure effects demonstration	when results are discussed with the class after the drying is completed. Are you prepared and ready for the whys asked by your students?

40. Student gluing samples	Students can prepare adhesion samples for a variety of explorations to find out why adhesives are selected for particular environments.
41. Equipment set-up	Shop improvised devices can be used to measure comparative results.
42. Equipment set-up	This torque wrench, measuring inch pounds, serves this test quite well.
43. Dry test results	Comparative results, again, are an important experience for the students.
44. Student preparing coatings	Coatings provide a rich field of investigations to be performed by students. This student is preparing test samples to be exposed to the weather.
45. Students evaluating wood	More questions are sure to result when the samples are examined after control time expires. This type of activity provides real eye-openers for both student and teacher.
46. Student loading die	Powdered metal materials can be compared to solid metal materials as to general properties in addition to discussing the process and use of powered metals in industry.
47. Teacher demonstrating	Powered metals in the classroom will cause interest and excitement with the students.
48. Teacher demonstrating	
49. Pellet results	Students need to be involved.
50. Student preparing metal	When using the microscope, careful preparation needs to be taken by the student to prepare the samples to be examined.
51. Student at microscope	The microscope can be a most valuable tool to demonstrate composition material.
52. Metal sample	Students will be more interested in their material when they can see the metal as shown,
53. Wood sample	or this sample of cedar wood.
54. Paper tensile testing	Devices need not be elaborate to demonstrate characteristics of materials.

55. Student at apparatus	The tensile strength of paper can effectively be compared and grain structure can be determined.
56. Corrosion activity setup	Corrosion of metals is easily demonstrated. Students can arrange different metal combinations to study results.
57. Chemical ion exchange	The study of the actual reaction that takes place will reinforce the students activity.
58. Results of five days	Several days of observation will bring home the message of corrosion.
59. Solutions and iron particles	Long range demonstration can be arranged by using different solutions, such as sea water, common drinking water, anti-freeze, and silicone dichromate.
60. Flame test on plastics	Flame testing of plastic materials will demonstrate particular properties of these new materials. Other interesting tests students could conduct is that of chemical corrosion, impact, and tensile strength.
61. Flame test on plastics	
62. Testing flexibility of metals	Bending characteristics of metals are vividly shown when comparing metals on simple testing device. Since comparative results are all that is necessary, real close measurements are not necessary.
63. Testing flexibility of metals	

At the conclusion of these slides, it is appropriate for the presenter to provide a summary statement as to applications that can be made to their situations.

RECOMMENDATIONS:

Several approaches can be used in presenting this idea of problem solving. Slides can be used and arranged in an order to complement the organization desired by the presenter. We would encourage the people that use these slides to investigate several approaches to presentation.

FILMS VIEWED DURING NDEA INSTITUTE, SUMMER, 1968
SAN JOSE STATE COLLEGE

ATOMIC POWER

POWER AND PROMISE
Jr. & Sr. High, Color
Building of the first atomic power plant. Discusses reaction and how the reactor works.
Evaluted by 14--good to excellent
Source #3

POWER REACTORS
Sr. High, Color, 16mm., 1958
Types of atomic reactors.
Evaluated by 5--good
Source #3

ADHESIVES

NEW HORIZONS FOR REINFORCED EPOXIES
Jr. & Sr. High, B & W, 16mm., 7 min., d & T
Surface coating application of concrete, wall board, and flooring.
Evaluated by 10--fair to good
Source #26

POLYSULFIDE BASE INDUSTRIAL SEALANT
Jr. & Sr. High, C, 16mm., 15 min.
Liquid polymer sealant and adhesive.
Evaluated by 5--fair
Source #25

CHEMISTRY

ACIDS, BASES, AND SALTS
Grades 10-12, Color, 16mm., 22 min., $120 B & W, $240 C
Explains the properties and uses of the important chemical compounds whose water solutions contain ions. Shows household and industrial uses.
Evaluated by 4--good
Source #6

CARBON AND ITS COMPOUNDS
Jr. & Sr. High, College, Color, 16mm., 11 min., $60 B & W, $120 Color
Explains carbon's simple compounds and introduces hydrocarbons and the more complex chain and ring compounds.
Rated by 13--old but good
Source #6

CHEMICAL BOND AND ATOMIC STRUCTURE
Sr. High, College, Color, 16mm., 16 min., $90 B & W, $180 Color
Animation and laboratory demonstrations show covalent, ionic, and metallic bonds and explains how bonding affects the physical and chemical properties of a substance.
Evaluated by 14--good to excellent
Source #6

CRYSTALS--AN INTRODUCTION
Sr. High, College, Color, 16mm., 25 min., 1959, price--free
Instructor's pamphlet available.
A bit long but shows formation of crystals and their characteristics. Film is for introducing the subject of crystallography by demonstrating the orderly arrangement of atoms in the crystalline state and the relationship of this arrangement to the physical properties of the substances.
Evaluated by 11--good to excellent
Source #18

EXPLORING THE ATOMIC NUCLEUS
Grade 10 to college, 16mm., Color, 13 min., $75 B & W, $150 Color
Shows recent discoveries in the atomic structure, along with the basic equipment used.
Evaluated by 5--no value
Source #6

PHYSICAL AND CHEMICAL CHANGE
Sr. High, College, B & W and Color, 28 min.
Evaluated by 2--poor
Source #6

PRINCIPLES OF IONIZATION
Sr. High, College, B & W, Color, 13 1/2 min.
Evaluated by 3--fair
Source #6

PROPERTIES OF ACIDS, BASES, AND SALTS
Sr. High, Color, 16mm., 28 min., $125 B & W, $250 Color
Properties of solutions of acids and bases are illustrated and tested.
Source #6

USING THE LABORATORY (CHEMISTRY AND PHYSICS)
General information for science classes.
Evaluated by 1--good
Source #6

CORROSION

CORROSION
Jr. & Sr. High, College, Color, 16mm., 26 min., 2 parts
Shows the oxide-metal-oxide cycle. 1st part uses animated sequences to describe the method by which stainless steels resist corrosive attack. 2nd part demonstrates statement of part 1.
Evaluated by 2--excellent
Source #23

CORROSION IN ACTION I, II, III
Sr. High, College, Color, 16mm., 1953, 3 reels, Part I (26 min.), Part II (17 min.)
Covers large areas of corrosion. Explains and demonstrates the nature of corrosion.
Evaluated by 6--excellent
Source #19

ZINC CONTROLS CORROSION
Color, 16mm., 38 min., Order #1627
Demonstrates the nature of corrosion and how zinc application guards against corroding element.
Source #14

ELECTRONICS

CERAMICS AND ELECTRONICS
Sr. High and College, Color, 16mm., 22 min., 1961
Production of porcelain terminals in electronic components. Importance of ceramic materials in the electronics industry.
Evaluated by 7--fair to good
Source #24

INFRARED
Sr. High, Color
A presentation of electromagnetic radiation.
Evaluated by 6--good
Source #1

IONIZATION
Sr. High, College, B & W, Color, 18 1/2 min.
Shows electron exchange
Evaluated by 3--good
Source #6

METAL

ALUMINUM--METAL OF MANY FACES
Jr. & Sr. High, College, Color, 16mm., 28 min.
Discusses aluminum and its properties. Processes of refining from mining to smelting. Corrosion-resistant, anodizing, permanent coloring.
Evaluated by 4--fair to good
Source #5

AUTOMATION IN THE METALLURGY LABORATORY
Sr. High, Color, 16mm., 30 min., free
A demonstration of modern methods of metallurgical sample preparation including cutting, grinding, mounting.
Evaluated by 1--good
Source #4

COLOR AND TEXTURE IN ALUMINUM FINISHES
Jr. & Sr. High, College, Color, 16mm., 18 min.
Too much promotion, little on materials or processes. Appliances, architectural and automotive applications.
Evaluated by 9--poor to fair
Source #2

HEAT TREATING OF STEEL--ELEMENTS _F HARDENING
Jr. & Sr. High, College, B & W, 16mm., 20 min.
Discusses the principles and procedures involved in tempering, normalizing, and annealing.
Evaluated by 23--excellent but old
Source #5

HEAT TREATMENT OF ALUMINUM
Sr. High, College, B & W, 16mm., 2 parts (I--20 min., II--24 min.)
Grains, slip planes, crystal lattice.
Evaluated by 12--good, old
Source #

HOW METALS BEHAVE
Sr. High, College
Evaluated by 7--good content but slightly long and boring
Source #

METAL CRYSTALS IN ACTION
Sr. High, Jr. College
Crystalline metal structures. Shows how grain structure affects physical properties.
Evaluated by 8--good
Source #14

MODERN METHODS FOR JOINING METALS
Sr. High, College, Color, 16mm., 20 min.
Filmed in metal fabricating plants and in Lindes' research and development laboratories. Illustrated Lindes' electric-welding processes and their applications in industry.
Evaluated by 10--good
Source #27

POWDER METALLURGY
B & W, 16mm., 19 min.
Applications of powder metallurgy.
Evaluated by 11--good to excellent
Source #

MISCELLANEOUS

ENGINEERING WITH GLASS
Grade--all levels, Color, 16mm., 28 min., 1962
Examines all types of glass and its uses. An extensive study in the properties of glass.
Evaluated by 4--good
Source #2

MINUS 320°
16mm., 14 min., free
"Operation Cryogenics" history, research, and a digest of the tests of results.
Evaluated by 13--interesting but not too useful
Source #2

THE NATURE OF GLASS
Color, 16mm., 37 min.
Demonstrates graphically through experimentation the technical degree to which glass characteristics can be varied and controlled.
Evaluated by 2--good
Source #2

THE SCIENCE OF FIRE
Color, 16mm., 20 min.
The scientific explanation of combustion flash points, ignition, temperatures, vapor, travel.
Evaluated by 6--good
Source #2

A TIP, A TOOL, A CHIP
Color, 16mm., 20 min.
Cemented carbides. Too much advertising.
Evaluated by 3--good
Source #28

UNDERWAY
Color, 16mm., 35 min.
General interest. Construction of U.S. Savannah 1959.
Evaluated by 7--fair to good
Source #3

PAINTS AND COATINGS

THE MAGIC TOUCH
Color, 16mm., 22 min., 1960, free
Shows how synthetic latex is manufactured. Covers four basic lattices. Explains action and reaction of monomers, polymers, and co-polymers and the resulting molecular chain.
Evaluated by 2--well done but not too informative

PAINT SCIENCE AND TECHNOLOGY
Source #8

RANSBURG ELECTROSTATIC PAINTING
Jr. & Sr. High, College, Color, 16mm., 22 min.
Sales pitch on electrostatic painting.
Evaluated by 4--fair
Source #12

WONDERFUL WORLD OF QUALITY PAINT
Jr. & Sr. High
Too much advertising but reviews paint production.
Evaluated by 5--poor to fair
Source #9

POLYMERS

DESIGN OF MOLDED PHENOLICS
B & W, 16mm., 30 min., 1956, free
A technical film on molding problems of phenolics. It does not tell anything about the nature of the phenolic material.
Evaluated by 5--good but not really usable
Source #26

FOCUS ON FOAM
Jr. & Sr. High, Color
Describes the differences in plastic foams with particular emphasis upon styrofoam in the construction industry.
Evaluated by 7--good
Source #7

THE MAGIC MOLECULE
Jr. High, 16mm.
Describes Marlyx (Philips Chem. Co. Plastic)--shows characteristics of their plastics.
Evaluated by 2--fair
Source #

MANUFACTURING REINFORCED PLASTICS
Source #20

MOLDING PHENOLICS
Sr. High, College, B & W, 16mm.
Discusses the types of molds used in the production of thermosetting plastics.
Evaluated by 3--good
Source #26

ORIGIN AND SYNTHESIS OF PLASTICS
Source #20

PHYSICAL CHEMISTRY OF POLYMERS
Color, 16mm., 22 min., 1962
Physical properties of polymers.
Evaluated by 2--very good to excellent
Source #18

PLASTICS--THE MIRACLE OF MODERN LIVING
Source #26

POWER

CRUDE OIL DISTILLATION
B & W, 16mm., 13 min.
Demonstrates fractionization. Distillation process and history, equipment used. Molecular changes. Tells how crude petroleum is composed of carbon and hydrogen atoms.
Evaluated by 6--fair to good
Source #22

FRONTIERS OF FRICTION
Color, 16mm., 18 min., free
How friction is used and how it is reduced by applied and pure research.
Evaluated by 15--good to excellent
Source #22

GREASE, THE MAGIC FILM
Jr. & Sr. High
Use of greases under different environments. Its manufacturing and proper uses.
Evaluated by 3--good
Source #17

HARNESSING LIQUIDS
B & W, 16mm., 12 min., free
Theory of hydraulics and how hydraulic power is used in brakes, hoists, and landing gear.
Evaluated by 4--old but good
Source #21

AN INTRODUCTION TO THE HEAT ENGINE
B & W, Jr. & Sr. High, 16mm., 23 min.
An introduction to the heat engine. Presentation of the theory and use of heat engines, as a source of power.
Evaluated by 4--poor (old)
Source #22

THE NATURE OF HEAT
Jr. & Sr. High, College, Color, 16mm., 12 min.
Three methods of heating.
Evaluated by 6--good
Source #6

OIL FILMS IN ACTION
Sr. High, Color, 16mm., 16 min.
Filmed in G. M. laboratories to show how oil films behave in bearings dealing with co-efficient of friction, one film pressure/load, viscosity.
Evaluated by 2--good
Source #10

POWER FOR PROGRESS
Source #15

PRESSURE IN FLUID AT REST
Sr. High mostly, but all levels, B & W, Color
Evaluated by 1--good
Source #6

RETURN FROM SPACE
Jr. & Sr. High, College, Color, 16mm., 29 min.
Many new ideas and tests being conducted by N.A.S.A.
Evaluated by 7--excellent
Source #15

RUBBER FROM OIL
Color, 30 min.
Shows how petroleum research by two young scientists more than 20 years ago led to the development of synthetic rubber, so important to our war effort.
Source #20

SPACECRAFT PROPULSION AND POWER
Jr. & Sr. High, College
Describes power systems on a spacecraft.
Evaluated by 2--good
Source #15

A SPARK IN TIME
Color, 16mm., 22 min., Order #2211
Auto ignition system
Source #14

STORY OF LUBRICATING OIL
Jr. & Sr. High, College, Color, 16mm.
Animated cartoons--oil refining and additives. Film is old.
Evaluated by 5--good
Source #5

WOOD

COMPARATIVE FIRE TEST ON TIMBER AND STEEL BEAMS
Jr. High & Sr. High, College, 16mm., Color
Wood vs. steel, under controlled conditions, in a fire test.
Evaluated by 4--good
Source #16

COMPARATIVE FIRE TEST ON WOOD AND STEEL JOISTS
Grades 11 & 12, Color, 16mm., 15 min.
Description of fire test on comparable steel and wood construction members. Draws several conclusions concerning usage of these materials.
Evaluated by 5--good
Source #16

SOURCES

1. Aerojet-General Corp.
Public Relations
Sacramento, Calif. 95813

2. Association Films
25358 Cypress Avenue
Hayward, California

3. A V Services
1840 Alcatraz Avenue
Berkeley, Calif. 94703

4. Buehler, Ltd.
2120 Greenwood Street
Evanston, Ill. 60204
(P. O. Box 830)

5. Bureau of Mines
U.S. Dept. of Interior
4800 Forbes Avenue
Pittsburg, Pa. 15213

6. Craig Corp., Coronet Films
3410 So. La Cienega Blvd.
Los Angeles, Calif. 90016

7. Dow Chemical Co.
AV Center-Film Library
Abbott Road Bldg.
Midland, Mich. 48540

8. Federation of Societies
for Paint Technology
121 S. Broad Street
Philadelphia, Pa. 19107

9. Fuller-O'Brien Corp.
1342 Willow Road
Menlo Park, Calif. 94025

10. General Motors Corp.
Staff Film Library
3044 W. Grand Blvd.
Detroit, Mich. 48202

11. Goodyear Tire & Rubber Co.
Public Relations Dept.
Akron, Ohio 44316

12. Ideal Pictures
15 E. Maryland
Indianapolis, Ind. 46204

13. Keystone Steel & Wire Co.
Venard Organization
Peoria, Illinois 61602

14. Modern Talking Picture Service
2238 Euclid Avenue
Cleveland, Ohio 44115

15. N.A.S.A. Manned Spacecraft
Center
Public Affairs Office
AP 2
Houston, Texas 77058

16. National Forest Products
Rm 213, Professional Building
El Cerrito Plaza
El Cerrito, Calif. 94530

17. National Lubricating Grease
Institute
4635 Wyandotte Street
Kansas City, Mo. 64112

18. Pacific Telephone Film Library
16 Spear Street
San Francisco, Calif. 94105

19. Rothacker, Inc.
241 West 17th Street
New York, New York 10011

20. Santa Clara County Audio Visual
Center
1110 N. 10th Street
San Jose, California

21. Shell Oil Co.
Film Library
430 Peninsular Avenue
San Mateo, Calif. 94401

22. Shell Oil Co.
Film Library
450 N. Meridian Street
Indianapolis, Ind. 46204

23. Syndicated Films, Inc.
1022 Forbes Avenue
Pittsburg, Pa. 15219

24. Tektronix, Inc.
Film Library
P. O. Box 500
Beaverton, Oregon 97005

25. Thiokol Chemical Corp.
Film Library
P. O. Box 27
Bristol, Pa. 19007

26. Union Carbide Corp.
Chemical and Plastics
1355 W. Front Street
Plainfield, New Jersey 07063

27. Union Carbide Corp.
Linde Division
22 Battery
San Francisco, Calif. 94106

28. Wesson Company
Marketing Service Department
800 Market Street
Waukegan, Ill. 60085